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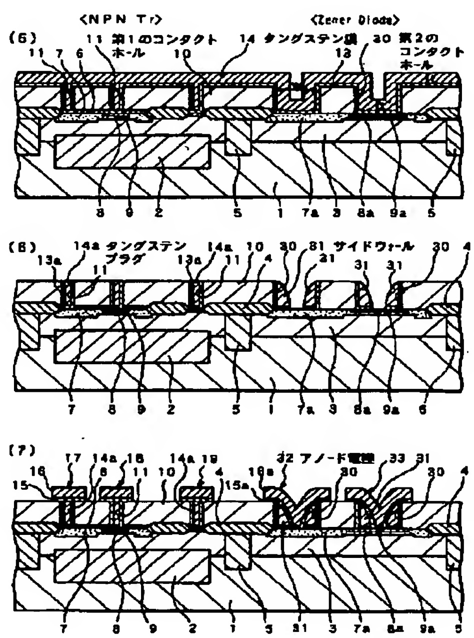
(54)【発明の名称】　半導体装置の製造方法および半導体装置

(57)【要約】
【課題】　微細化のためにタングステン（Ｗ）プラグ技術を採用し、しかもツェナーザップダイオードを破壊短絡した際フィラメントを安定して形成できるようにした、半導体装置とその製造方法の提供が望まれている。
【解決手段】　絶縁膜１０に形成された第１のコンタクトホール１１にＷプラグ１４ａが設けられた半導体素子と、絶縁膜１０に形成された第２のコンタクトホール３０上にアノード電極３２を有したツェナーザップダイオードとを備えた半導体装置の製造方法である。第２のコンタクトホール３０内をＷで満たすことなく第１のコンタクトホール１１をＷで埋め込み、エッチバックして第１のコンタクトホール１１内にＷプラグ１４ａを形成するとともに、第２のコンタクトホール３０内にシリコン基板１表面を露出させ、第２のコンタクトホール３０内に、シリコン基板１表面に導通するアノード電極３２を形成する。



【特許請求の範囲】

【請求項１】　シリコン基板上の絶縁膜に形成された第１のコンタクトホールにタングステンプラグが設けられてなる半導体素子と、前記絶縁膜に形成された第２のコンタクトホール上にアルミニウムあるいはアルミニウム合金からなるアノード電極を有したツェナーザップダイオードとを備えた半導体装置の製造方法であって、
前記絶縁膜に第１のコンタクトホール、第２のコンタクトホールをそれぞれ形成した後、第２のコンタクトホール内をタングステンで満たすことなく第１のコンタクトホールをタングステンで埋め込む第１の工程と、
前記タングステンをエッチバックして第１のコンタクトホール内にタングステンプラグを形成するとともに、第２のコンタクトホール内にシリコン基板表面を露出させる第２の工程と、
前記第２のコンタクトホール内に、露出したシリコン基板表面に導通するアルミニウムあるいはアルミニウム合金からなるアノード電極を形成する第３の工程と、を備えたことを特徴とする半導体装置の製造方法。

【請求項２】　前記第１の工程を、ＣＶＤ法でタングステンを成膜することによって行うとともに、このタングステン膜の膜厚を、前記第２のコンタクトホールの幅の１／２より薄くすることにより、該第２のコンタクトホール内をタングステンで満たさないようにした、ことを特徴とする請求項１記載の半導体装置の製造方法。

【請求項３】　シリコン基板上の絶縁膜に形成された第１のコンタクトホールにタングステンプラグが設けられてなる半導体素子と、前記絶縁膜に形成された第２のコンタクトホール上にアルミニウムあるいはアルミニウム合金からなるアノード電極を有したツェナーザップダイオードとを備えた半導体装置において、
前記第２のコンタクトホールの側壁に、タングステンからなるサイドウォールが該第２のコンタクトホールの底部にシリコン基板表面を露出させた状態に形成され、
この第２のコンタクトホール内に、露出したシリコン基板表面に導通するアルミニウムあるいはアルミニウム合金からなるアノード電極が形成されてなることを特徴とする半導体装置。

【請求項４】　前記サイドウォールが、前記タングステンプラグ形成の際のタングステンの成膜、およびこれに続くエッチバックによって形成されたものであり、前記第２のコンタクトホールの幅が、前記タングステンの成膜により得られるタングステン膜の膜厚の２倍を越えて形成されている、ことを特徴とする請求項３記載の半導体装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、タングステンプラグを有した半導体素子とツェナーザップダイオードとを備えた半導体装置と、その製造方法に関する。

【０００２】

【従来の技術】近年、電子機器では、その備品点数を減らすためＬＳＩ等からなる半導体装置の高精度化が要求されており、このような要求に応えるための一手段として、ツェナーザッピングによりＬＳＩの抵抗等を調整する技術が知られている。このツェナーザッピングを行うためのダイオード、すなわちツェナーザップダイオードは、一般にはＮＰＮトランジスタのエミッタ／ベースを利用することが多いものの、近年では、ＮＰＮトランジスタと製造プロセスを共有化して同じジャンクションを利用しつつ、平面的にはＮＰＮトランジスタと別の領域に形成する構成のものも提供されている。

【０００３】また、ＬＳＩ等の半導体装置では、高集積化を図るべく微細化が進められており、このような微細化を進めた結果、特に０．５μｍルール以下のプロセスのもとで基板と上部配線との間のコンタクトを作製する場合、アルミニウムでは埋め込み性が不十分であることから、タングステンプラグ技術が採用されるようになっている。

【０００４】図３、図４は、このような従来のＮＰＮトランシスタとツェナーザップダイオードとを備え、さらにタングステンプラグ技術を採用した半導体装置の製造方法を、工程順に説明するための図である。以下、これらの図に基づいて従来の製造方法を説明する。

【０００５】まず、図３の（１）に示すようにＰ型のシリコン基板１のＮＰＮトランジスタ形成領域にN^+コレクタ埋め込み層２を形成する。続いて、既存のエピタキシャル成長技術により、シリコン基板１上にＮ型エピタキシャル層３を形成する。次に、図３の（２）に示すようにＬＯＣＯＳ法によってフィールド酸化膜４を形成し、続いて、例えばホウ素（Ｂ）をイオン注入することによってＰ型素子分離領域５を形成する。

【０００６】次いで、図３の（３）に示すようにシリコン基板１表面にバッファ膜６を形成し、続いて、例えばBF_2をイオン注入することによってＮＰＮトランジスタ形成領域に外部ベース７を形成するとともに、ツェナーザップダイオード形成領域にアノードコンタクト７ａを形成する。次いで、BF_2を高濃度でイオン注入することにより、ＮＰＮトランジスタ形成領域にベース８を形成するとともにツェナーザップダイオード形成領域にアノード８ａを形成する。

【０００７】次いで、図３の（４）に示すように例えばリン（Ｐ）またはヒ素（Ａｓ）をイオン注入することにより、ＮＰＮトランジスタ形成領域にエミッタ９およびコレクタコンタクト９ｂを形成するとともに、ツェナーザップダイオード形成領域にカソード９ａを形成し、これによってＮＰＮトランジスタとツェナーザップダイオードとをそれぞれ得る。続いて、シリコン基板１上にフィールド絶縁膜１０を形成する。

【０００８】次いで、図４の（５）に示すように公知の

リソグラフィー技術、エッチング技術により、ＮＰＮトランジスタのエミッタ９／ベース８／コレクタ９ｂにそれぞれ通じる第１のコンタクトホール１１と、ツェナーザップダイオードのアノード８ａ／カソード９ａにそれぞれ通じる第２のコンタクトホール１２とをフィールド絶縁膜１０に形成する。ここで、これら第１のコンタクトホール１１、第２のコンタクトホール１２については、これらの間に差をつけることなく同じ形状・寸法に形成する。

【０００９】次いで、スパッタ法によってＴｉ系合金を成膜することにより密着層１３を形成し、続いて、ＣＶＤ法によってタングステンを成膜することにより、第１のコンタクトホール１１、第２のコンタクトホール１２を共に埋め込みこれらを満たした状態にタングステン膜１４を形成する。

【００１０】次いで、作製したタングステン膜１４、密着層１３をエッチバックし、図４の（６）に示すようにフィールド絶縁膜１０上のタングステン膜１４、密着層１３を除去して第１のコンタクトホール１１、第２のコンタクトホール１２内にそれぞれ密着層１３ａを介してタングステンプラグ１４ａを形成する。

【００１１】次いで、スパッタ法等によってＴｉ系合金とアルミニウム（あるいはアルミニウム合金）とをこの順に成膜し、その後、公知のリソグラフィー技術、エッチング技術によってこれらをパターニングすることにより、対応するタングステンプラグ１４ａに接続するようにして、図４の（７）に示すようにバリアメタルとなるＴｉ系合金１５とＡｌあるいはＡｌ系合金１６とからなるベース電極１７、エミッタ電極１８、コレクタ電極１９、アノード電極２０、カソード電極２１をそれぞれ形成する。

【００１２】このようにして得られた半導体装置にあっては、前記ツェナーザップダイオードでその抵抗を調整する場合、通常、調整箇所となるツェナーザップダイオードのアノード８ａとカソード９ａとの間、すなわちアノード電極２０とカソード電極２１との間に逆バイアスを印加し、これらの間を破壊短絡させる。このような破壊短絡は、逆バイアス印加によってアノード電極２０中のＡｌがカソード９ａ側に移動し、Ａｌとシリコン基板１のＳｉとが反応してこれらの合金からなるフィラメントが形成されることによって起こる。

【００１３】

【発明が解決しようとする課題】しかしながら、前述した従来の半導体装置では、破壊短絡させるべく逆バイアスをかけた際、アノード電極２０の下のタングステンプラグ１４ａ、さらにはその下の密着層１３ａがアノード電極２０中のＡｌのカソード９ａ側への移動を阻んでしまう。このようにしてＡｌの移動が阻まれると、ＡｌとＳｉとからなるフィラメントが形成されにくくなり、甚だしい場合にはアノード電極８ａとカソード電極９ａとが十分に短絡しなくなり、当初の目的である抵抗調整が不十分になってしまう。

【００１４】本発明は前記事情に鑑みてなされたもので、その目的とするところは、微細化のためにタングステンプラグ技術を採用し、しかもツェナーザップダイオードを破壊短絡した際フィラメントを安定して形成できるようにした、半導体装置とその製造方法を提供することにある。

【００１５】

【課題を解決するための手段】本発明の半導体装置の製造方法では、シリコン基板上の絶縁膜に形成された第１のコンタクトホールにタングステンプラグが設けられてなる半導体素子と、前記絶縁膜に形成された第２のコンタクトホール上にアルミニウムあるいはアルミニウム合金からなるアノード電極を有したツェナーザップダイオードとを備えた半導体装置の製造方法において、前記絶縁膜に第１のコンタクトホール、第２のコンタクトホールをそれぞれ形成した後、第２のコンタクトホール内をタングステンで満たすことなく第１のコンタクトホールをタングステンで埋め込む第１の工程と、前記タングステンをエッチバックして第１のコンタクトホール内にタングステンプラグを形成するとともに、第２のコンタクトホール内にシリコン基板表面を露出させる第２の工程と、前記第２のコンタクトホール内に、露出したシリコン基板表面に導通するアルミニウムあるいはアルミニウム合金からなるアノード電極を形成する第３の工程と、を備えたことを前記課題の解決手段とした。

【００１６】この半導体装置の製造方法によれば、タングステンを成膜する際、このタングステンで第２のコンタクトホール内を満たすことなく第１のコンタクトホールをタングステンで埋め込むようにしたので、その後タングステンをエッチバックすることにより第１のコンタクトホール内にタングステンプラグを形成するとともに、第２のコンタクトホール内にシリコン基板表面を露出させることができ、したがってこの第２のコンタクトホール内にアノード電極を形成することにより、タングステンプラグを介することなくこのアノード電極を露出したシリコン基板表面に導通させることが可能になる。

【００１７】また、本発明の半導体装置では、シリコン基板上の絶縁膜に形成された第１のコンタクトホールにタングステンプラグが設けられてなる半導体素子と、前記絶縁膜に形成された第２のコンタクトホール上にアルミニウムあるいはアルミニウム合金からなるアノード電極を有したツェナーザップダイオードとを備えてなり、前記第２のコンタクトホールの側壁に、タングステンからなるサイドウォールが該第２のコンタクトホールの底部にシリコン基板表面を露出させた状態に形成され、この第２のコンタクトホール内に、露出したシリコン基板表面に導通するアルミニウムあるいはアルミニウム合金からなるアノード電極が形成されてなることを前記課題

の解決手段とした。

【００１８】この半導体装置によれば、第２のコンタクトホール内に、露出したシリコン基板表面に導通してアノード電極が形成されているので、ツェナーザップダイオードを破壊短絡させるとき、アノード電極中のアルミニウムがタングステンプラグに阻まれることなくカソード側に移動し、これによりＡｌ－Ｓｉからなるフィラメントが安定して形成されるようになる。さらに、第２のコンタクトホールの側壁にタングステンからなるサイドウォールが形成されているので、この第２のコンタクトホール内に形成されたアノード電極が、サイドウォール上に形成されていることによりカバレージが良好なものとなって断線の心配がないものとなり、またサイドウォール自体も電極として機能することによりエレクトロマイグレーションによる断線も防止されたものとなる。

【００１９】

【発明の実施の形態】以下、本発明を詳しく説明する。図１、図２は、本発明の半導体装置の製造方法の一実施形態例を工程順に説明するための図である。以下、これらの図に基づいて本発明の製造方法の一実施形態例を詳しく説明する。なお、本例においても、作製する半導体装置としては、図３、図４に示した従来のものと同様に、ＮＰＮトランシスタとツェナーザップダイオードとを備え、さらにタングステンプラグ技術を採用したものとする。また、図３、図４に示した構成要素と同一の構成要素については同一の符号を付している。

【００２０】まず、図１の（１）に示すように従来と同様にして、Ｐ型のシリコン基板１のＮＰＮトランジスタ形成領域にN^+コレクタ埋め込み層２を形成する。続いて、既存のエピタキシャル成長技術により、シリコン基板１上にＮ型エピタキシャル層３を形成する。

【００２１】次に、図１の（２）に示すようにＬＯＣＯＳ法によってフィールド酸化膜４を形成し、続いて、例えばホウ素（Ｂ）をイオン注入することによってＰ型素子分離領域５を形成する。ただし、本例においては、後に形成する第２コンタクトホールを、図４の（１）～（３）に示した従来の第２のコンタクトホール１２に比べその幅を広く形成するため、ツェナーザップダイオードの形成領域が図３、図４に示した例より広くなるようにして、フィールド酸化膜４を形成する。

【００２２】次いで、図１の（３）に示すように従来と同様にして、シリコン基板１表面にバッファ膜６を形成し、続いて、例えばBF_2をイオン注入することによってＮＰＮトランジスタ形成領域に外部ベース７を形成するとともに、ツェナーザップダイオード形成領域にアノードコンタクト７ａを形成する。次いで、BF_2を高濃度でイオン注入することにより、ＮＰＮトランジスタ形成領域にベース８を形成するとともにツェナーザップダイオード形成領域にアノード８ａを形成する。

【００２３】次いで、図１の（４）に示すように従来と

同様にして、例えばリン（Ｐ）またはヒ素（Ａｓ）をイオン注入することにより、ＮＰＮトランジスタ形成領域にエミッタ９およびコレクタコンタクト９ｂを形成するとともに、ツェナーザップダイオード形成領域にカソード９ａを形成し、これによってＮＰＮトランジスタとツェナーザップダイオードとをそれぞれ得る。続いて、シリコン基板１上にフィールド絶縁膜１０を形成する。

【００２４】次いで、図２の（５）に示すように公知のリソグラフィー技術、エッチング技術により、ＮＰＮトランジスタのエミッタ９／ベース８／コレクタ９ｂにそれぞれ通じる第１のコンタクトホール１１と、ツェナーザップダイオードのアノード８ａ／カソード９ａにそれぞれ通じる第２のコンタクトホール３０とをフィールド絶縁膜１０に形成する。ここで、本例においては、第２のコンタクトホール３０の幅Ｗを、後に成膜して形成するタングステン膜の膜厚の２倍を越えて形成する。

【００２５】次いで、スパッタ法によってＴｉ系合金を成膜することにより密着層１３を形成し、続いて、ＣＶＤ法によってタングステンを成膜することにより、第２のコンタクトホール３０内をタングステンで満たすことなく、第１のコンタクトホール１１をタングステンで埋め込んでこれをタングステンで満たした状態にして、タングステン膜１４を形成する。

【００２６】ここで、このタングステン膜１４の膜厚ｔについては、前述したように該第２のコンタクトホール３０の幅Ｗがタングステン膜１４の膜厚ｔの２倍を越えるように、すなわちこのタングステン膜１４の膜厚ｔが第２のコンタクトホール３０の幅Ｗの１／２より薄くなるようにして形成する。ただし、ここでいうタングステン膜１４の膜厚ｔとは、厳密には密着層１３の膜厚をも含めた厚さである。しかして、密着層１３の膜厚はタングステン膜１４単体の膜厚に比べて十分に薄く、実質的にはタングステン膜１４単体の膜厚がこのタングステン膜１４単体の膜厚と密着層１３の膜厚との合計にほぼ等しいことから、これらタングステン膜１４単体と密着層１３との膜厚の合計を、本発明においては「タングステン膜の膜厚ｔ」と記している。

【００２７】このようにして密着層１３、タングステン膜１４を形成すると、タングステン膜１４の膜厚ｔ（厳密にはタングステン膜１４単体の膜厚と密着層１３の膜厚との合計）を第２のコンタクトホール３０の幅Ｗの１／２より薄く形成していることから、図２の（５）に示したように第２のコンタクトホール３０内では、前述したようにこの第２のコンタクトホール３０内がタングステンで満たされることなく、その底部及び側壁部にのみタングステンが堆積した状態となる。

【００２８】次いで、作製したタングステン膜１４、密着層１３をエッチバックして図２の（６）に示すようにフィールド絶縁膜１０上のタングステン膜１４、密着層１３を除去する。このようにしてエッチバックを行う

と、第１のコンタクトホール１１内に密着層１３ａを介してタングステンプラグ１４ａを形成することができ、また、第２のコンタクトホール３０内においては、その側壁に密着層１３とタングステン膜１４とからなるサイドウォール３１を形成することができる。なお、このようにしてエッチバックを行って第２のコンタクトホール３０内にサイドウォール３１を形成すると、この第２のコンタクトホール３０内の底部では、サイドウォール３１、３１間にてシリコン基板１の表面が露出する。

【００２９】これは、前述したように第２のコンタクトホール３０内にタングステンを満たさないようにしてタングステン膜１４を形成していることから、該第２のコンタクトホールの底部において堆積したタングステン膜１４の膜厚ｔ' がフィールド絶縁膜１０上のタングステン膜１４の膜厚ｔにほぼ等しくなり、したがってフィールド絶縁膜１０上のタングステン膜１４を除去するようにしてエッチバックすることにより、第２のコンタクトホールの底部に堆積したタングステン膜１４についてもこれが除去されるからである。

【００３０】次いで、従来と同様にしてスパッタ法等でＴｉ系合金とアルミニウム（あるいはアルミニウム合金）とをこの順に成膜し、その後、公知のリソグラフィー技術、エッチング技術によってこれらをパターニングする。すると、ＮＰＮトランジスタ形成領域においては、従来と同様に第１のコンタクトホール１１内の対応するタングステンプラグ１４ａに接続するようにして、図２の（７）に示すようにバリアメタルとなるＴｉ系合金１５とＡｌあるいはＡｌ系合金１６とからなるベース電極１７、エミッタ電極１８、コレクタ電極１９がそれぞれ形成される。

【００３１】一方、ツェナーザップダイオードの形成領域においては、第２のコンタクトホール３０内にてシリコン基板１表面が露出しているので、この露出したシリコン基板１表面に導通し、さらにフィールド絶縁膜１０上にまで延びた状態で、Ｔｉ系合金１５ａとＡｌあるいはＡｌ系合金１６ａとからなるアノード電極３２、およびカソード電極３３がそれぞれ形成され、これにより本発明の半導体装置が作製される。

【００３２】このような半導体装置にあっては、ツェナーザップダイオードでその抵抗を調整する場合、従来のものと同様に調整箇所となるツェナーザップダイオードのアノード８ａとカソード９ａとの間、すなわちアノード電極３２とカソード電極３３との間に逆バイアスを印加し、これらの間を破壊短絡させる。すると、本例のものにおいては、アノード電極３２がタングステンプラグを介することなく第２のコンタクトホール３０内にて基板１表面に導通しているので、アノード電極３２中のアルミニウムが容易にカソード９ａ側に移動し、これによりＡｌ－Ｓｉからなるフィラメントが安定して形成されるようになる。したがって、本例の半導体装置にあっては、その抵抗調整操作を容易にかつ確実に行うことができるものとなる。

【００３３】また、第２のコンタクトホール３０にタングステンからなるサイドウォール３１を形成したので、この第２のコンタクトホール３０内に形成したアノード電極３２のカバレージを良好にすることができ、したがってカバレージ不良に起因するアノード電極３２の断線を防止することができるとともに、サイドウォール３０自体も電極として機能することによりエレクトロマイグレーションによる断線も防止することができる。

【００３４】なお、前記実施形態例では、本発明をＮＰＮトランジスタとツェナーザップダイオードとを備えた半導体装置とその製造方法に適用したが、本発明はこれに限定されることなく、ＮＰＮトランジスタに代えてＰＭＯＳやＮＭＯＳ、ＣＭＯＳ等の半導体素子を備えた半導体装置とその製造方法に適用することもできる。

【００３５】

【発明の効果】以上説明したように本発明の半導体装置の製造方法は、タングステンを成膜する際、このタングステンで第２のコンタクトホール内を満たすことなく第１のコンタクトホールをタングステンで埋め込むようにした方法であるから、その後タングステンをエッチバックすることにより第１のコンタクトホール内にタングステンプラグを形成するとともに、第２のコンタクトホール内にシリコン基板表面を露出させることができ、したがってこの第２のコンタクトホール内にアノード電極を形成することにより、タングステンプラグを介することなくこのアノード電極を露出したシリコン基板表面に導通させることができる。

【００３６】よって、このようにして得られた本発明の半導体装置は、アノード電極が露出したシリコン基板表面に導通して形成されているので、ツェナーザップダイオードを破壊短絡させるとき、アノード電極中のアルミニウムがタングステンプラグに阻まれることなくカソード側に移動し、これによりＡｌ－Ｓｉからなるフィラメントが安定して形成されるようになり、したがってその抵抗調整操作を容易にかつ確実に行うことができるものとなる。

【００３７】さらに、第２のコンタクトホールの側壁にタングステンからなるサイドウォールが形成されているので、この第２のコンタクトホール内に形成されたアノード電極が、サイドウォール上に形成されていることによりカバレージが良好なものとなって断線の心配がないものとなり、またサイドウォール自体も電極として機能することによりエレクトロマイグレーションによる断線も防止されたものとなり、したがってこの半導体装置は信頼性の高いものとなる。

【図面の簡単な説明】

【図１】（１）～（４）は、本発明の半導体装置の製造方法の一実施形態例を工程順に説明するための要部側断

面図である。

【図２】（５）～（７）は、本発明の半導体装置の製造方法の一実施形態例を説明するための図であり、図１の（４）に続く工程を順に説明するための要部側断面図である。

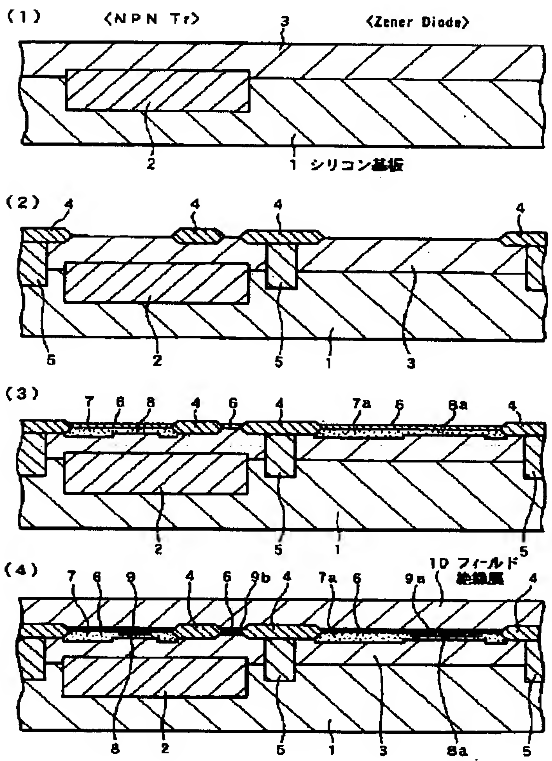
【図３】（１）～（４）は、従来の半導体装置の製造方法の一例を工程順に説明するための要部側断面図である。

＊【図４】（５）～（７）は、従来の半導体装置の製造方法の一例を説明するための図であり、図３の（４）に続く工程を順に説明するための要部側断面図である。

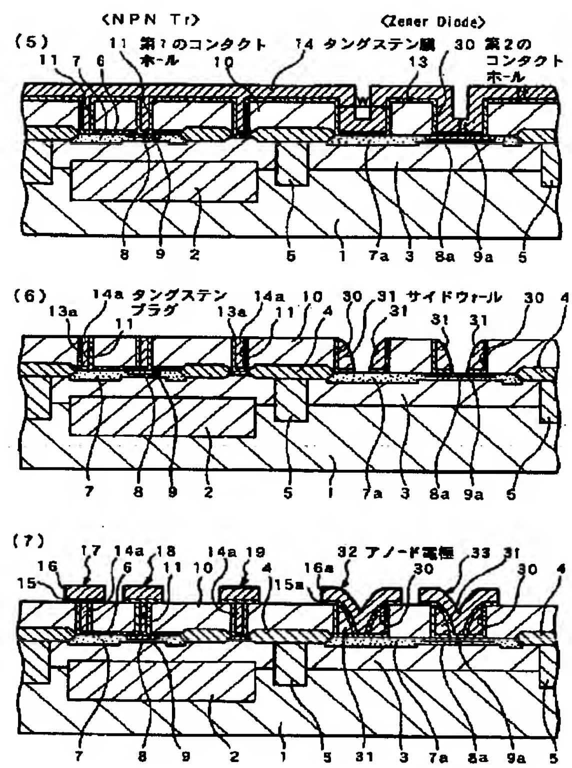
【符号の説明】

１…シリコン基板、１０…フィールド絶縁膜、１１…第１のコンタクトホール、１４…タングステン膜、１４ａ…タングステンプラグ、３０…第２のコンタクトホール、３１…サイドウォール、３２…アノード電極

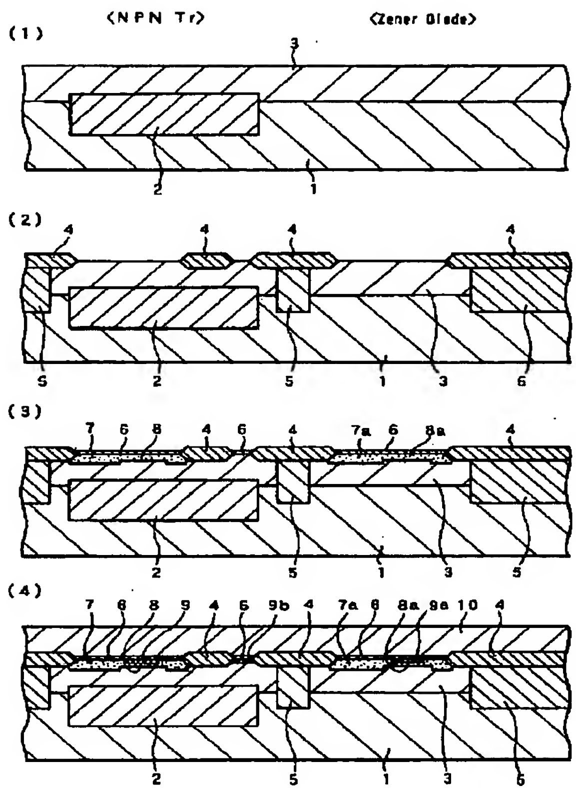
【図１】



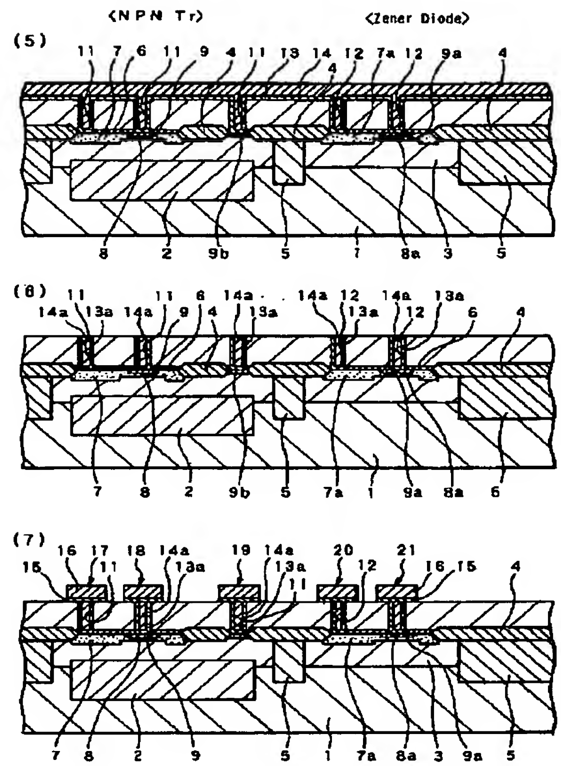
【図２】



【図３】



【図４】



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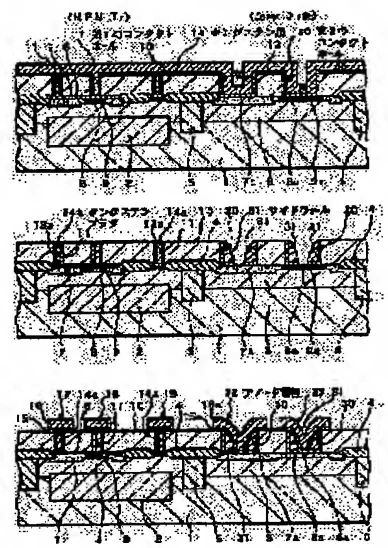
(54) SEMICONDUCTOR DEVICE AND MANUFACTURE OF THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To adopt a tungsten (W) plugging technique for making it minute and furthermore to enable a filament to be formed stably, when a Zener-zap diode is broken down and short-circuited.
SOLUTION: A semiconductor device is equipped with a semiconductor element, where a W plug 14a is provided in a first contact hole 11 bored in an insulating film 10 and a Zener-zap diode provided with an anode electrode 32 on a second contact hole 30 bored in the insulating film 10, and the device is manufactured by a method, where the inside of a second hole 30 is not filled with W, but the first contact hole 11 is filled up with W, a W plug 14a is formed inside the first contact hole 11 by etching back, the surface of a silicon substrate 1 is exposed in the second contact hole 30, and the anode electrode 32 that continues to the surface of the silicon substrate 1 is formed inside the second contact hole 30.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the robot control system to which a robot is moved, starting the robot control system for carrying out the remote monitor of a plant, the works, etc. using a robot, especially uniting autonomous control and remote control.
[0002]
[Description of the Prior Art] When the mobile robot for carrying out the remote monitor of a plant, the works, etc. was used from the former, there were an approach of roughly dividing and moving all mobile robots by remote operation, and a method of making of operation [all] give a mobile robot autonomously.
[0003] although the motion of a robot is fundamentally supervised with the TV camera etc. by the approach by remote operation, since there is little information acquired compared with viewing in a TV camera, compared with the case where it is accepting reality, it is markedly alike, and actuation is difficult and an operator's burden is also large [actuation].
[0004] Therefore, a mistake arises by the immaturity of an operator's technique, fatigue, etc., a mobile robot cannot avoid risk of an obstruction etc. or there is a possibility of colliding with surrounding people and a surrounding object. Moreover, if the situation where the communication link with a mobile robot is stopped in cutoff of the electric wave by failure of a communication device, a building, etc. also produces the skilled operator, stop instruction for risk aversion etc. cannot be given to a mobile robot, but even if sensing will be carried out a mobile robot conversely (a surrounding image, contact on a body on the street, etc.), un-arranging [that an operator cannot recognize it] will arise.
[0005] By furthermore, the reasons nil why low-cost-izing or infrastructure development of the means of communications of an operator and a mobile robot are not ready etc. If communication link delay arises by transmission through two or more paths etc. when means of communications with small channel capacity is being used for example Since an operator has to give the command of passing speed, a direction, etc. based on a mobile robot's sensor information (a robot location, bearing, image information, etc.) transmitted behind time, the command will also be overdue and a mobile robot will be reached, The operability of the real time to a mobile robot gets very bad. Therefore, when sudden obstructions, such as a pedestrian, appear on a mobile robot's path, a mobile robot cannot be stopped immediately.
[0006] On the other hand, when making a mobile robot do autonomous working, the dependability of migration has required the mobile robot itself for the ability to recognize [which] a surrounding environment correctly, and the following points pose a problem.
(1) the dependability of sensing -- for example "Stentz, A., Hebert, M., and "A Complete Navigation System for GoalAcquisition in Unknown Environment" and Proc.of IEEE International Conference on

Intelligent Robots and Systems'95", Although the example of an experiment which carries out autonomous migration is stated to pp.425-432 and 1995" (reference 1) while a vehicle mold mobile robot uses a laser distance sensor for the inside of a strange environment and detects a surrounding failure When distance detection is not completed on the water surface etc., it is necessary to operate it by human being wedging himself in autonomous control of a mobile robot.

[0007] moreover, to the trend of the autonomous mobile robot research in "carat appearance Takeo and the U.S., JRSJ, Vol.5, No.5, pp.41-51, and 1987" (reference 2) Although the example which carries out autonomous migration of the same vehicle mold mobile robot in the environments (the road where pavement is imperfect, the road which has a shadow on a road surface, road where fallen leaves exist) of an outdoor indeterminate is described The travel speed is not it being as late as 0.6km/about h, and moving by any scenes to stability moreover.

(2) Although the route when carrying out autonomous migration of the vehicle mold mobile robot from a starting point to the destination is shown, the incompleteness 1, for example, the reference, of a migration plan, for trial-and-error, the detour was performed repeatedly and the useless motion of the motion of the first half has increased. That is, what can advance to the destination that human being taught the root more simply [way] may happen. And the algorithm for generally generating the root in autonomous migration is complicated.

(3) Although connected also with an expensive sensing system (1), in order to raise the dependability of sensing from the former, to unite sensor information of a different kind (sensor fusion) is tried. However, generally the cost in connection with sensing increases, and a system becomes expensive. For example, although the sensor system with a precision of 10mm which combined GPS (Global Positioning System), the engine-speed sensor (encoder) of a wheel, and the inertia sensor unit (three accelerometers, three gyroscopes) as a terrestrial location detection means is formed in the vehicle mold mobile robot shown in reference 1, the cost is about 1 million$ (about 120 million yen).

[0008] By the way, in order to cope with it inconvenient [actuation of the mobile robot only by remote control which was mentioned above or autonomous control], in recent years, try, both sides are made to specifically share knowledge, and the attempt whose operator and robot are made to cooperate mutually and with which autonomous control and remote control are united according to an activity is made. Making an operator's burden light and attaining the increase in efficiency of an activity by this, is expected.

[0009] For example, autonomous remote fusion control of a double arm hyperdactyly form manipulator besides "Shimizu (the 1st news), The Robotics Society of Japan academic lecture meeting, pp.263-264, 1990" (reference 3), "Autonomous remote fusion control of a double arm hyperdactyly form manipulator besides Omichi (the 2nd news), Japan Society of Mechanical Engineers ROBOTTIKUSU mechatoronics lecture meeting'91 lecture collected works (Vol.A), "pp.49-50 and 1991" (reference 4), the activation-teaching method in autonomous remote fusion control besides Omichi, To the Robotics Society of Japan academic lecture meeting, pp.569-570, and 1990" (reference 5) The example which applied such an autonomous remote fusion control robot to the double arm hyperdactyly mold master slave robot is described, and there is a publication about spatial fusion and time fusion as an approach of combining autonomous control and remote control.

[0010] It is possible spatial fusion to use some degrees of freedom of a manipulator for remote control, and to be the approach of using the remainder for autonomous control, for example, to make the left arm of a manipulator into autonomous mode in slinging-work actuation, to make a hook grasp, to make a right arm into a remote mode, and to make a wire hung.

[0011] However, the base itself is moving and, moreover, unlike actuation of a manipulator, a mobile robot cannot catch a sight of the whole mobile robot from outside. Therefore, a role assignment of autonomous control and remote control cannot be easily performed like the manipulator mentioned above. Moreover, it is very difficult for a surrounding environmental variation to predict a surrounding

situation in a manipulator, since a surrounding environment changes every moment by the mobile robot to there being much self, i.e., the thing which arises as a result of the activity of a manipulator, and being able to predict.
[0012] The above problem forms a camera in the interior of a mobile robot temporarily, and since it is a problem produced even if it operates by remote control, while an operator looks at the image sent by the mobile robot, it cannot form the fusion plan of autonomous working and remote actuation beforehand like a manipulator. Therefore, it can be said that it is difficult to perform spatial fusion in a mobile robot.

[0013] On the other hand, time fusion is the approach of uniting remote actuation for autonomous working in time according to a robot's working hours. It is also possible for there to be a concept of a time dial in this time fusion, as shown in reference 2, for example, to turn back actuation of a manipulator in time. However, since the base is being fixed, a manipulator can return the same hand orbit, but since there is no base fixed in the mobile robot, there is a problem that the same orbit cannot be returned.
[0014]
[Problem(s) to be Solved by the Invention] Although there were two moving methods of migration only by remote operation and migration only by autonomous working in the conventional mobile robot as mentioned above, there was a problem that actuation is difficult for the former, and it was difficult to cope with the situation where generating of an obstruction etc. is insufficient, appropriately since it may be able to stop being able to operate it on real time according to a communication link condition. Moreover, the latter had a possibility that a robot could stop being able to operate appropriately and a useless motion might increase, and had the problem that a sensing system became expensive. Furthermore, applying the fusion approach of of autonomous control and remote control, such as spatial fusion and time fusion, to a mobile robot had the problem of being difficult.
[0015] This invention is for solving such a problem, autonomous control and remote control can be combined appropriately, it is cheap and an operator's burden aims at offering the robot control system which can also cope with the insufficient situation easily few moreover.
[0016]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, this invention is a robot control system to which this robot is moved by performing data communication between a robot and an operating set. An operating set A display means to display the data transmitted by the data and the robot which were set up beforehand in order to teach a robot, It has an instruction means for teaching the moving-target data of the action module unit which should be transmitted to a robot on the display screen of this display means. A robot A knowledge base storage means by which the knowledge base for the autonomous migration set up beforehand was memorized, A decision means to judge whether the autonomous migration based on the knowledge base memorized by this knowledge base storage means is possible, When it is judged by this decision means that the autonomous migration based on the knowledge base is possible, autonomous migration is performed based on the knowledge base. When it is judged that the autonomous migration based on the knowledge base is impossible, after degenerating current autonomous migration, It is characterized by having an autonomous migration means to perform autonomous migration based on the moving-target data to which the situation data in which a current situation is shown were taught by the operating set with the instruction means based on delivery and this situation data. Here, in order to teach a robot at a display means, the data transmitted by the data and the robot which were set up beforehand are displayed on two or more coincidence, respectively.
[0017]
[Embodiment of the Invention] Hereafter, the operation gestalt which applied this invention to the autonomous remote fusion control system with reference to the drawing is explained.

(1st operation gestalt) Drawing 1 is drawing having shown the appearance of the autonomous remote fusion control system concerning the 1st operation gestalt, (a) expresses the robot which moves the inside of a plant etc., and (b) expresses a robot's operating set. Moreover, drawing 2 is the block diagram having shown a robot's configuration, and drawing 3 is the block diagram having shown the configuration of an operating set.

[0018] This autonomous remote fusion control system consists of communication devices 3a and 3b for roughly dividing and communicating between a robot 1, an operating set 8, and a robot 1 and an operating set 8. A robot 1 operates by autonomous remote fusion control with which autonomous control and remote control were united. Namely, a subject of operation and operations sequence are set as the robot 1 as the knowledge base (environmental model). When a robot 1 operates autonomously while the part in which autonomous working is possible took the check to the operator based on the environmental model, and lack is in the information on an environmental model, That is, when it cannot respond only for the information on an environmental model, such as generating of an obstruction 14, and lapses into the condition in which its action decision is impossible, that is communicated to an operating set 8 and an operator is asked for subsequent concrete directions. If an operator inputs the directions according to this with an operating set 8, the instruction data is sent to a robot 1, and a robot 1 will make the instruction data reflect in an environmental model, and will resume autonomous working. In addition, same processing is performed also when performing the instruction of a robot 1 between which an operator intervenes free working (activation-instruction), for example, the instruction equivalent to correction of a location posture.

[0019] Hereafter, the configuration of each part is explained to a detail. As shown in drawing 1 (a), the robot 1 is constituted as a wheel mold robot which moves by four wheels 5, and CCD camera 2, the distance robot 4, the encoder 6, and the gyroscope 7 are formed as a sensing means. That is, a robot 1 incorporates surrounding image information with CCD camera 2 as sensor information, detects the distance to the obstruction 14 which exists ahead in predetermined distance by the distance robot 4, detects the rotation of a wheel 5 with an encoder 6, and detects the direction of a body (posture) with a gyroscope 7.

[0020] Here, it is easy to be the thing of extent which can recognize the obstruction 14 which exists on a robot's 1 course at least as a distance robot 4, and it cannot be necessary to recognize clearly what the obstruction 14 is. For example "Illah R.Nourbakhsh and David Andre, CarloTomasi, and and To Michael R.Genesereth, "Obstacle Avoidance Via Depth From Focus", and ARPA Image Understanding Workshop 1996" (reference 6) Although the method of planning distance from the dotage condition of an image as a cognitive system is indicated By photoing the image of a front fixed distance by the distance sensor 4 similarly, and detecting the distance from the dotage condition of the image to the obstruction in an image, in the recognition precision of an obstruction 14, although it is inferior, positive sensing is realizable. However, when using an ultrasonic sensor, since detection when the reflector of an obstruction 14 inclines is difficult for a supersonic wave, it is desirable [when using a laser range finder as a distance robot 4, detection of the distance over the obstruction 14 of a black field is difficult for laser light, and / a supersonic wave] to use other sensors together.

[0021] Communication device 3a for communicating with an operating set 8 if needed is prepared for the robot 1. In addition, since an operating set 8 only gives the command of the action module unit (action level) of the robots 1 which do not give the command of movement control level on real time to a robot 1, for example, show the destination on a 2-dimensional map, such as coordinate data, as communication device 3a, real time nature, such as PHS (Personal Handyphone System), may not necessarily be guaranteed.

[0022] Furthermore, the picture compression section 21 for compressing into a robot 1 the image photoed with CCD camera 2 to be shown in drawing 2 , The knowledge base section 23 the knowledge base for the autonomous migration set up beforehand (environmental model) is remembered to be, The

decision section 24 which judges whether the autonomous migration based on the knowledge base is possible, and the dead REKONINGU section 25 for measuring a robot's 1 center-of-gravity location with autonomous migration and remote migration are formed. In addition, in this drawing, the control device 22 is formed by the knowledge base section 23, the decision section 24 and the dead REKONINGU section 25, and communication device 3a, and it considers as migration of a robot 1 and the thing by which the rotational frequency of each wheel 5 is specifically controlled with this control device 22.

[0023] On the other hand, as shown in drawing 1 (b), the operating set 8 is constituted by communication device 3b, the image display machine 9, data storage 10, the data-conversion processor 11, the mouse 12, and the loudspeaker 13.

[0024] The 2-dimensional map information (line drawing) corresponding to a mobile robot's 1 successive ranges (for example, site of works etc.) set up beforehand be memorize as data required for data storage 10 in order to teach a robot 1 the migration root, and the 2-dimensional map corresponding to a required part be display by an operator's selection on the screen of the image display machine 9.

[0025] The image display machine 9 is for displaying the static-image information sent by the robot 1, displaying the independent image of the 2-dimensional map information (line drawing) memorized by data storage 10, or displaying these compound images by multi-window. Here, the image display machine 9 shall make a display image zooming or the thing which is made to advance side by side and rotate and can be displayed free, and shall perform selection of the display image of business from from among two or more display images. Moreover, the image display machine 9 is used also in the case of the moving trucking instruction to a robot 1. Namely, as shown in drawing 3 , the pointer P on the screen of the image display machine 9 can be operated with a mouse 12, and directions of the destination etc. can be given to a robot 1 now.

[0026] The data-conversion processor 11 performs zooming of line information, such as the focus on the 2-dimensional map memorized by data storage 10, and a border of a road, coordinate transformation processing of advancing side by side and a rotation, etc.

[0027] Hereafter, the processing when moving this robot 1 by autonomous remote fusion control is explained. First, a robot's 1 destination is directed by the operator in an operating set 8. Specifically with an operating set 8, a 2-dimensional map is independently displayed on the image display machine 9 based on the 2-dimensional map information memorized by data storage 10. An operator inputs a robot's 1 destination into an operating set 8 by clicking one on the 2-dimensional map displayed on the image display machine 9 with a mouse 12. Thus, the coordinate data on the 2-dimensional map showing the destination of the inputted robot 1 is sent to a robot 1 by communication device 3b as instruction data through the data-conversion processor 11. However, a robot's 1 destination may be beforehand set as the knowledge base section 23 by the side of a robot 1 in sequence.

[0028] A robot 1 makes the instruction data received by communication device 3a reflect in the knowledge base, based on the knowledge base, to the destination, unites autonomous migration and remote migration and moves. That is, a robot 1 moves by autonomous migration fundamentally based on the contents of a setting of the knowledge base section 23 (2-dimensional map information, the criteria information on migration, etc. are included besides the migration root). And only when action decision is itself impossible, an operator gives a robot 1 directions.

[0029] Specifically, a robot 1 does autonomous migration by carrying out dead REKONINGU from a its present location to the destination at the shape of the shape of a straight line, and a curve (for example, radii) set up beforehand. That is, a robot's 1 dead REKONINGU section 25 measures a robot's 1 center-of-gravity location based on the data of the direction of a robot 1 (posture) detected with the rotation and gyroscope 7 of each wheel 5 which were detected by the encoder 6. A control device 22 controls the engine speed of each wheel 5 based on the measurement result of the dead REKONINGU section 25, and a robot 1 does autonomous migration as the result.

[0030] Moreover, in order to correct the error by slipping of a wheel 5 etc., it is made the criteria of a robot's 1 migration of suitable things, such as a curbstone path on the street, and may be made to move by learning to the criteria. The indicator formed in along a manhole besides the curbstone which was learned and was mentioned above as criteria of migration, and a road, the white line drawn on a path on the street can be considered.
[0031] Thus, while performing autonomous migration, by the robot 1, it judges whether instruction of action is required of a being [performing autonomous migration succeedingly based on the knowledge base / possible], and operating set 8 side. Specifically, a robot's 1 decision section 24 degenerates the action at the time to the level which can once secure insurance as that which lapsed into the condition in which the action decision (autonomous migration) only by the robot 1, i.e., the knowledge base, is impossible, when it judges whether an obstruction 14 exists in the fixed distance on a course from the detection result of a distance robot 4 and the obstruction 14 has be recognize. In this case, it is not necessary to recognize what that obstruction 14 is concretely that what is necessary is to recognize that an obstruction 14 exists as mentioned above.
[0032] A robot 1 uses a rate as degeneration of action. That is, a control device 22 secures insurance when an obstruction 14 exists on a course by controlling the rotational speed of each wheel 5 and adjusting the passing speed of the robot 1 whole. At this time, if a robot's 1 rate is made into zero and stopped immediately, the maximum reservation of the insurance can be carried out. Moreover, if it carries out adjustable [of a robot's 1 rate] according to the distance to an obstruction 14, useless transit time can be shortened. In the case of the latter, if the distance to an obstruction 14 is near, a robot's 1 rate will be lowered, and if the distance to an obstruction 14 is far, a rate will be gathered in the possible range.
[0033] Thus, after degenerating action on the level which can secure insurance, a robot 1 transmits the static-image information on the obstruction 14 obtained with CCD camera 2, and the distance information to the obstruction 14 obtained by the distance robot 4 to an operating set 8 by communication device 3a as information which shows a current situation, and becomes the remote operation from an operating set 8, i.e., a directions waiting state. In addition, the direction (posture) information of the robot 1 not only with static-image information or distance information but the gyroscope 7 mentioned above, the rotation information on the wheel 5 by the encoder 6, etc. can be transmitted to an operating set 8. Furthermore, the sound around [which was measured with the sound-collecting microphone etc.] a robot 1 may be transmitted to an operating set 8.
[0034] By communication device 3b, an operating set 8 receives the static-image information and distance information which were transmitted by the robot 1, and displays a static image on the image display machine 9 first. Next, static-image information is analyzed on the basis of distance information, the 2-dimensional map information corresponding to the location shown with a static image is called from data storage 10, and the 2-dimensional map (line drawing) corresponding to the image display machine 9 with a static image is piled up and displayed.
[0035] However, since a robot 1 does not have the fixed base and a wheel 5 may slip, even if it is performing dead REKONINGU processing mentioned above, the location cannot always be measured correctly. Therefore, if a static image and a 2-dimensional map are piled up and displayed on the image display machine 9, the focus or the line which carry out phase correspondence with a static image and a 2-dimensional map may not lap correctly. In this case, suitable coordinate transformation processings, such as zooming, and advancing side by side and a rotation, are performed to the 2-dimensional map information on original, and it is made for the focus and the line of a static image and a 2-dimensional map which carry out phase correspondence to pile up correctly on the screen of the image display machine 9 with the data-conversion processor 11.
[0036] Drawing 4 is the example which showed the static image displayed on the image display machine 9, and the 2-dimensional map. In this case, on the screen, a robot's 1 current location R, the

planned autonomous root 41, and its obstruction 42 which exists previously are shown. Moreover, in this example, since the edge AB of the road surface on a static image and marginal A'B' of the road surface to which it corresponds on a 2-dimensional map did not pile up correctly, advancing side by side and rotational coordinate processing are performed to the 2-dimensional map. In addition, phase correspondence of the pole 43 on a screen can be carried out, and coordinate transformation processing can also be performed.
[0037] Next, an operator operates a mouse 12, looking at the screen of the image display machine 9, and inputs the moving point which should be directed to a robot 1. In this case, the location (point) of the safe autonomous orbit (henceforth, amendment orbit) which can avoid an obstruction 42 shall be directed, and with one point directions on a screen, when useless, two or more points are directed. For example, in drawing 4 , it means that the amendment orbit for avoiding an obstruction 42 was inputted by clicking a mouse 12 in order of Points a and b, and finally clicking the returning point C on the autonomous root. When shifting a robot 1 from the autonomous root 41, a robot 1 enables it to return to the original autonomous root 41 like this example, as the returning point C on the autonomous root 41 is given. You may make it search for the orbit which can return to the autonomous root 41 most smoothly by the operation at this time.
[0038] Next, in an operating set 8, the coordinate data on the 2-dimensional map of each point is changed into the data of an amendment orbit, and the instruction data to a robot 1 with the data-conversion processor 11 in fact, and this is transmitted to a robot 1 by communication device 3b.
[0039] By the way, in an operating set 8, in parallel to the processing for inputting the amendment orbit mentioned above, a suitable beep sound is emitted from a loudspeaker 13, and cautions are demanded from an operator. At this time, a beep sound is changed from a robot 1 according to the size of the distance to an obstruction 14 based on the distance information sent by the robot 1. For example, when distance is near, sound volume is enlarged, and sound volume is made small when far. Moreover, when distance is near, it is a high sound, and when far, it can be made to change [sound / low] (it changes one octave at the maximum and the minimum value of for example, detection distance).
[0040] This beep sound is emitted until the instruction data of an amendment orbit are sent to a robot 1, or until there is a communication link which shows that the obstruction 14 was avoided from the robot 1 and it returned to the original autonomous migration.
[0041] If communication device 3a receives the instruction data of an amendment orbit, the robot 1 which was in the state waiting for directions from an operating set 8 will move so that an obstruction 14 may be avoided according to the instruction data (remote migration). However, a robot 1 moves autonomously according to the instruction data of an amendment orbit in fact. And after being able to return from an amendment orbit to an original autonomous orbit, in accordance with the autonomous orbit of a body, autonomous migration is continued as it is. in addition, after degenerating action similarly when an obstruction 14 is generated ahead while performing autonomous migration according to the amendment orbit, it is desirable to require directions of the further amendment orbit of an operator -- in this way In autonomous remote fusion control of this operation gestalt, autonomous migration of the robot 1 is carried out according to the knowledge base fundamentally memorized by the knowledge base section 23. When an obstruction 14 etc. is generated ahead of a robot 1 and it becomes impossible to be unable to respond for the information only on the knowledge base section 23, a robot's 1 action is degenerated and an operating set 8 is asked for subsequent directions by communication device 3a. And a robot 1 is moved based on the instruction data sent from the operating set 8 according to it, and after returning to an original autonomous orbit, it is made to perform autonomous migration succeedingly. Thus, since autonomous control and remote control can be united appropriately and a robot 1 can be moved, an operator's burden decreases compared with the case where all are depended on remote control, and it can respond also to generating of an obstruction 14 appropriately. Moreover, since a robot 1 may not have the advanced autonomy of a like when performing autonomous control altogether, he

can build the whole including a sensing means cheaply.
[0042] Moreover, since a robot 1 degenerates autonomous migration first and he is demanding directions of an operating set 8 when an obstruction 14 is generated ahead, also when people cross a robot's front, for example, he can fully secure the insurance of a robot 1 and each man. Since the robot 1 is moved autonomously after that, it becomes unnecessary and to secure the communication link of real time between a robot 1 and a communication device 8 like [in the case of depending all on remote control] that an operating set 8 should just return directions of a robot's 1 action module unit (action level) like the coordinate data on a 2-dimensional map to the demand from a robot 1. Therefore, it can be stabilized even if communication link delay occurs between a robot 1 and an operating set 8, and a robot 1 can be operated. Moreover, communicative real time nature is able to use what is not necessarily guaranteed like PHS as communication devices 3a and 3b.
[0043] On the other hand, since the 2-dimensional map memorized by the static image sent by the robot 1 in the operating set 8 and data storage 10 is piled up and displayed on the image display machine 9 when operating by remote control, an operator can grasp a robot's 1 present condition exactly. Since the focus path on the street, such as a manhole, the border of a road, etc. can be doubled with the static image and 2-dimensional map to which the 2-dimensional map was sent by the robot 1 zooming, advancing side by side, and by making it rotate and displaying with the data-conversion processor 11 at this time, a robot's 1 condition can be grasped easily.
[0044] Moreover, since an operator can show a robot's 1 amendment orbit only by choosing the point considered as the request on the screen of the image display machine 9 using a mouse 12, he can perform easily remote control for making a robot 1 avoid from an obstruction 14.
[0045] Furthermore, in the operating set 8, when there is a directions demand from a robot 1, the beep sound is generated from the loudspeaker 13. And since the sound volume and the frequency of a beep sound are changed from the robot 1 according to the distance to an obstruction 14 based on the distance information sent by the robot 1, an operator can judge a robot's 1 condition correctly.
[0046] Next, a formula is shown and explained about the example of dead REKONINGU in a robot 1. First, when performing dead REKONINGU based on the rotation of the wheel 5 detected by the encoder 6 (encoder method), the robot body 1000 is divided into right and left, and it is considered that it called it the right wheel 1101 and the left wheel 1102, the right encoder 501, and the left encoder 502 as shown in drawing 8 . Moreover, it is LC about the distance between wheels of the right wheel 1101 and the left wheel 1102. It carries out.
[0047] Amount of advance deltaER calculated from the count of the right encoder 501 in the sampling time at this time Amount of advance deltaEL similarly calculated from the count of the left encoder 502 under sampling It is based and inclination deltatheta of the right and left produced during the sampling is shown like a degree type.
deltatheta= (deltaER-deltaEL) / LC -- (1)
Moreover, the amount ER of right wheel advance And the amount EL of left wheel advance It is shown like a degree type.
[0048]
[Equation 1]

$$\left.\begin{aligned} E_R &= \pi D \frac{C_R}{C_0} \cdot K_R \\ E_L &= \pi D \frac{C_L}{C_0} \cdot K_L \end{aligned}\right\} \quad \cdots (2)$$

C_0 ：１回転あたりのカウント数

C_R ：右車輪エンコーダカウント数

C_L ：左車輪エンコーダカウント数

D ：車輪直径

K_R ：右車輪補正係数

K_L ：左車輪補正係数

E_R ：右車輪進行量

E_L ：左車輪進行量

On the other hand, it is the initial value theta 0 of an inclination. It is based and current inclination theta is shown like a degree type.
[0049]
theta=integral deltathetadt+theta 0 -- (3)
Furthermore, amount of advance deltar to the travelling direction within the sampling time is shown like a degree type.
deltar= (deltaEL+deltaER)/2 -- (4)
In this case, it is [0050] when a formula (4) is divided into x components and y component.
[Equation 2]

$$\left.\begin{aligned} \Delta x &= \Delta r \cdot \cos\theta \\ \Delta y &= \Delta r \cdot \sin\theta \end{aligned}\right\} \quad \cdots (5)$$

Δx ：サンプリング時間内のｘ方向への進行量

Δy ：サンプリング時間内のｙ方向への進行量

In **, the initial value of the center-of-gravity location of a body can be calculated for the present center-of-gravity location of a body (xG and yG) like a degree type as (x0 and y0).
[0051]
[Equation 3]

$$\left.\begin{aligned} x_G &= \int \Delta x\, dt + x_0 \\ y_G &= \int \Delta y\, dt + y_0 \end{aligned}\right\} \quad \cdots (6)$$

[0052] On the other hand, when performing dead REKONINGU using a gyroscope 7 (gyroscope method), it is detection value thetaj from a gyroscope 7. thetaj and initial value are shown in the angular velocity from a gyroscope 7 like a degree type as thetaj0 (it is usually 0 in a start-up condition).
[0053]
thetaj =theta j dt+theta j0 -- (7)
It is based on this formula (7) and is a robot's 1 transit direction value xj. And the infestation direction value yj It asks like a degree type and things are made.

[0054]
[Equation 4]

$$\left.\begin{aligned} X_j &= \int \Delta r \cdot \cos\theta_j \, dt + x_{j0} \\ y_j &= \int \Delta r \cdot \sin\theta_j \, dt + y_{j0} \end{aligned}\right\} \quad \cdots (8)$$

x_{j0}：走行方向初期値

y_{j0}：横行方向初期値

[0055] Next, a formula is shown and explained about the example when displaying a static image and a 2-dimensional map (line drawing) on the image display machine 9 of an operating set 8. First, as shown in drawing 5 (a), the ground system of coordinates (X, Y, Z) of Zero O and a robot's 1 location are Zero OV. As indicated in drawing 5 (b) as the becoming robot system of coordinates (XV, YV, and ZV), the camera system of coordinates (XC, YC, ZC) by CCD camera 2 are considered. However, at robot system of coordinates, it is XV about a robot's 1 front. It is YV about the forward direction of a shaft, and the left. It is ZV about the forward direction of a shaft, and the direction of a vertical. It is made to correspond in the forward direction (for it to be a ground top ZV =0) of a shaft, and is XC about the direction of an optical axis of CCD camera 2 at camera system of coordinates. It is made to correspond in the forward direction of a shaft.
[0056] Moreover, the point P on a robot map [in / by the following explanation / ground system of coordinates] (X, Y, Z) The point of robot 1 core in ground system of coordinates PG (XG, YG, and ZG), A robot's 1 bearing in ground system of coordinates psi (it is forward about a counterclockwise rotation to the X-axis), The coordinate when seeing Point P by robot system of coordinates PV (XV, YV, and ZV), The home position of the camera system of coordinates seen from robot system of coordinates PB (XB, YB, and ZB), The coordinate when seeing Point P by camera system of coordinates PC (XC, YC, and ZC), Coordinate PC in the flat surface (henceforth, pixel flat surface) at which the picture element of CCD camera 2 was constituted together with length and width The number of pixels in every direction within (deltax, delta y), and a pixel flat surface is expressed [a projecting point] for the scale of (x, y), and a pixel flat surface as (ixall:width and iyALL:length).
[0057] First, it changes into the coordinate PV (XV, YV, and ZV) which looked at the point P on the robot map in ground system of coordinates (X, Y, Z) by robot system of coordinates using the degree type. In addition, in order to simplify count, a robot 1 is on a flat surface and assumes that it is Z= 0.
[0058]
[Equation 5]

$$\begin{bmatrix} X_V \\ Y_V \\ Z_V \end{bmatrix} = \begin{bmatrix} \cos\phi & \sin\phi & 0 \\ -\sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \left[\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} - \begin{bmatrix} X_G \\ Y_G \\ Z_G \end{bmatrix} \right] \quad \cdots (9)$$

ただし、Z_V, Z, $Z_G = 0$

Next, it changes into the coordinate PC (XC, YC, and ZC) which looked at Coordinate PV (XV, YV, and ZV) with the camera coordinate using the degree type.
[0059]
[Equation 6]

$$\begin{bmatrix} X_C \\ Y_C \\ Z_C \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & -\sin\theta \\ 0 & 1 & 0 \\ \sin\theta & 0 & \cos\theta \end{bmatrix} \left[\begin{bmatrix} X_V \\ Y_V \\ Z_V \end{bmatrix} - \begin{bmatrix} X_B \\ Y_B \\ Z_B \end{bmatrix} \right] \quad \cdots (10)$$

ただし、$Z_V = 0$

（$[X_B, Y_B, Z_B]$，θはデータ入力できる様にする）

In this case, when a formula (9) is calculated, it comes to be shown in a degree type, and it is [0060].

[Equation 7]

$$\begin{bmatrix} X_V \\ Y_V \\ Z_V \end{bmatrix} = \begin{bmatrix} (X-X_G)\cos\phi & (Y-Y_G)\sin\phi & 0 \\ -(X-X_G)\sin\phi & (Y-Y_G)\cos\phi & 0 \\ 0 & 0 & 0 \end{bmatrix} \quad \cdots (11)$$

When a formula (10) is calculated, it comes to be shown in a degree type.

[0061]

[Equation 8]

$$\begin{bmatrix} X_C \\ Y_C \\ Z_C \end{bmatrix} = \begin{bmatrix} (X_V - X_B)\cos\phi + Z_B \cdot \sin\theta \\ (X_V - X_B) \\ (X_V - X_B)\sin\phi - Z_B \cdot \cos\theta \end{bmatrix} \quad \cdots (12)$$

[0062] Therefore, based on a formula (11) and a formula (12), it is convertible for the coordinate PC (XC, YC, and ZC) which looked at the point P on a robot map (X, Y, Z) by camera system of coordinates. Next, as shown in drawing 6 , the coordinate PC (XC, YC, and ZC) searched for from the formula (12) is projected on a pixel flat surface, as it is shown by the degree type.

[0063]

[Equation 9]

$$\left.\begin{aligned} x : f = Y_C : X_c &\longrightarrow x = \frac{Y_C}{X_C} f \\ y : f = Z_C : X_c &\longrightarrow y = \frac{Z_C}{X_C} f \end{aligned}\right\} \text{(距離単位)} \quad \cdots (13)$$

$$\left.\begin{aligned} i_x &= x \times \frac{i_{xALL}}{\Delta x} \\ i_y &= y \times \frac{i_{yALL}}{\Delta y} \end{aligned}\right\} \text{(画素単位)} \quad \cdots (14)$$

In this case, if two-point assignment (ix1, iy1) ((ix2, iy2)) of the coordinate within the pixel flat surface of a pixel unit (ix and iy) is carried out, the straight line which connects two points can be made on a pixel flat surface. A line drawing can be displayed on the image display machine 9 as mentioned above.

[0064] Next, the processing which puts a line drawing on a static image on the screen of the image display machine 9 is considered. First, actuation for putting line drawing A'B' on the part AB to which it corresponds on a static image is performed by the operator on a screen as shown in drawing 7 .

[0065] That is, an operator operates a mouse 12 and clicks Point A (Point A blinks at this time). If the

location of Point A is right, an operator will push a carriage turn key and will decide Point A. Hereafter, a total of four points are decided in order of point A', Point B, and point B'. In addition, if an error is in assignment of a point by actuation the middle, assignment actuation of the point will be initialized with an escape key.

[0066] Thus, after deciding four points, an operator pushes a carriage-return key, makes line drawing A'B' advance side by side, makes it rotate further, and doubles with Part AB. That is, point A' is made in agreement with Point A, and point B' is made in agreement with Point B. As a part AB, the descriptions, such as an angle of a road and an angle of a building, consider as an intelligible location.

[0067] Thus, with the data-conversion processor 11, if an operator decides all the points A and B, A', and B', in order to change the point of the arbitration of a static image into the point on a 2-dimensional map, it will ask for the parameter of coordinate transformation in a procedure which is described below.

[0068] First, it asks for whether the points A and B clicked with the mouse are equivalent to which pixel coordinate A [xA and yA] and B [xB and yB] on a pixel flat surface (distance unit), and asks for coordinate A[on the line drawing of point A' and B'] ' [XA and YA], and B' [XB and YB] further. And it asks for the parameter of coordinate transformation by counting relational expression backward, as shown below.

[0069]

[Equation 10]

$$\begin{bmatrix} X_{VA} \\ Y_{VA} \\ 0 \end{bmatrix} = \begin{bmatrix} \cos\phi & \sin\phi & 0 \\ -\sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \left\{ \begin{bmatrix} X_A \\ Y_A \\ 0 \end{bmatrix} - \begin{bmatrix} X_G \\ Y_G \\ 0 \end{bmatrix} \right\} \quad \cdots (15)$$

$$\begin{bmatrix} X_{CA} \\ Y_{CA} \\ Z_{CA} \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & -\sin\theta \\ 0 & 1 & 0 \\ \sin\theta & 0 & \cos\theta \end{bmatrix} \left\{ \begin{bmatrix} X_{VA} \\ Y_{VA} \\ 0 \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ Z_B \end{bmatrix} \right\} \quad \cdots (16)$$

$$\left. \begin{aligned} x_A &= \frac{Y_{CA}}{X_{CA}} f \\ y_A &= \frac{Z_{CA}}{X_{CA}} f \end{aligned} \right\} \quad \cdots (17)$$

$$\begin{bmatrix} X_{VB} \\ Y_{VB} \\ 0 \end{bmatrix} = \begin{bmatrix} \cos\phi & \sin\phi & 0 \\ -\sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \left\{ \begin{bmatrix} X_B \\ Y_B \\ 0 \end{bmatrix} - \begin{bmatrix} X_G \\ Y_G \\ 0 \end{bmatrix} \right\} \quad \cdots (18)$$

$$\begin{bmatrix} X_{CB} \\ Y_{CB} \\ Z_{CB} \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & -\sin\theta \\ 0 & 1 & 0 \\ \sin\theta & 0 & \cos\theta \end{bmatrix} \left\{ \begin{bmatrix} X_{VB} \\ Y_{VB} \\ 0 \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ Z_B \end{bmatrix} \right\} \quad \cdots (19)$$

$$\left. \begin{aligned} x_B &= \frac{Y_{CB}}{X_{CB}} f \\ y_B &= \frac{Z_{CB}}{X_{CB}} f \end{aligned} \right\} \quad \cdots (20)$$

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Hereafter, it is referred to as theta= 0 as easiest conditions. Moreover, cosphi is written as cphi and sinphi is written as sphi. In this case, relational expression as shown in a degree type from a formula (15) - a formula (17) is obtained.
[0070]
[Equation 11]

$$\left.\begin{aligned} X_{CA}\begin{bmatrix}1\\ x_A/f\\ y_A/f\end{bmatrix} &= \begin{bmatrix}c\phi & s\phi & 0\\ -s\phi & c\phi & 0\\ 0 & 0 & 1\end{bmatrix}\left\{\left\{\begin{bmatrix}X_A\\ Y_A\\ 0\end{bmatrix}-\begin{bmatrix}X_G\\ Y_G\\ 0\end{bmatrix}\right\}-\begin{bmatrix}0\\ 0\\ Z_B\end{bmatrix}\right\} \\ X_{CB}\begin{bmatrix}1\\ x_B/f\\ y_B/f\end{bmatrix} &= \begin{bmatrix}c\phi & s\phi & 0\\ -s\phi & c\phi & 0\\ 0 & 0 & 1\end{bmatrix}\left\{\left\{\begin{bmatrix}X_B\\ Y_B\\ 0\end{bmatrix}-\begin{bmatrix}X_G\\ Y_G\\ 0\end{bmatrix}\right\}-\begin{bmatrix}0\\ 0\\ Z_B\end{bmatrix}\right\}\end{aligned}\right\} \quad \cdots (21)$$

From this formula (21) [to 0071 [furthermore,]]
[Equation 12]

$$\begin{aligned} X_{CA}\begin{bmatrix}1\\ x_A/f\\ y_A/f\end{bmatrix} - X_{CB}\begin{bmatrix}1\\ x_B/f\\ y_B/f\end{bmatrix} &= \begin{bmatrix}c\phi & s\phi & 0\\ -s\phi & c\phi & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}X_A - X_B\\ Y_A - Y_B\\ 0\end{bmatrix} \\ &= \begin{bmatrix}X_A - X_B & Y_A - Y_B & 0\\ Y_A - Y_B & -(X_A - X_B) & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}c\phi\\ s\phi\\ 0\end{bmatrix}\end{aligned} \quad \cdots (22)$$

$$\begin{bmatrix}c\phi\\ s\phi\\ 0\end{bmatrix} = \begin{bmatrix}\dfrac{-(X_A - X_B)}{-\alpha} & \dfrac{-(Y_A - Y_B)}{-\alpha} & 0\\ \dfrac{-(Y_A - Y_B)}{-\alpha} & \dfrac{X_A - X_B}{-\alpha} & 0\\ 0 & 0 & 1\end{bmatrix}\left\{X_{CA}\begin{bmatrix}1\\ x_A/f\\ y_A/f\end{bmatrix} - X_{CB}\begin{bmatrix}1\\ x_B/f\\ y_B/f\end{bmatrix}\right\} \quad \cdots (23),$$

$$\therefore \begin{bmatrix}c\phi\\ s\phi\\ 0\end{bmatrix} = \begin{bmatrix}\dfrac{X_A - X_B}{\alpha}(X_{CA} - X_{CB}) + \dfrac{Y_A - Y_B}{\alpha}\left(X_{CA}\dfrac{x_A}{f} - X_{CB}\dfrac{x_B}{f}\right)\\ \dfrac{Y_A - Y_B}{\alpha}(X_{CA} - X_{CB}) - \dfrac{X_A - X_B}{\alpha}\left(X_{CA}\dfrac{x_A}{f} - X_{CB}\dfrac{x_B}{f}\right)\\ X_{CA}\dfrac{y_A}{f} - X_{CB}\dfrac{y_B}{f}\end{bmatrix} \quad \cdots (24)$$

It becomes. However, alpha= (XA-XB) 2+(YA-YB) 2 -- (25)
It comes out. Next, it is [0072] from relational expression called cphi2+sphi2 =1.
[Equation 13]

$$\frac{(X_A - X_B)^2 + (Y_A - Y_B)^2}{\alpha^2} \left\{ (X_{CA} - X_{CB})^2 + \left(X_{CA}\frac{x_A}{f} - X_{CB}\frac{x_B}{f} \right)^2 \right\} = 1 \quad \cdots (26)$$

(21) より

$$\left. \begin{aligned} X_{CA} &= -Z_B \cdot \frac{f}{y_A} \\ X_{CB} &= -Z_B \cdot \frac{f}{y_B} \end{aligned} \right\} \quad \cdots (27)$$

It becomes. Next, it is [0073] by substituting a formula (27) for a formula (26).
[Equation 14]

$$\frac{1}{\alpha} \left\{ \left(-Z_B \frac{f}{y_A} + Z_B \frac{f}{y_B} \right)^2 + \left(-Z_B \cdot \frac{x_A}{y_A} + Z_B \cdot \frac{x_B}{y_B} \right)^2 \right\} = 1 \quad \cdots (28)$$

$$\frac{Z_B^2}{\alpha} \left\{ f^2 \left(\frac{1}{y_A} - \frac{1}{y_B} \right)^2 + \left(\frac{x_A}{y_A} - \frac{x_B}{y_A} \right)^2 \right\} = 1 \quad \cdots (29)$$

$$f^2 (y_B - y_A)^2 + (x_A y_B - x_B y_A)^2 = \frac{\alpha}{Z_B^2} (y_A y_B)^2 \quad \cdots (30)$$

$$\therefore \quad f = \sqrt{\frac{\frac{\alpha}{Z_B^2} (y_A y_B)^2 - (x_A y_B - x_B y_A)^2}{(y_A - y_B)^2}} \quad \cdots (31)$$

It becomes. Next, it is [0074] from a formula (24), a formula (27), and the relational expression tanphi=sphi/cphi.
[Equation 15]

$$\tan\phi = \frac{(Y_A - Y_B)(X_{CA} - X_{CB}) - (X_A - X_B)\left(X_{CA}\frac{x_A}{f} - X_{CB}\frac{x_B}{f}\right)}{(X_A - X_B)(X_{CA} - X_{CB}) + (Y_A - Y_B)\left(X_{CA}\frac{x_A}{f} - X_{CB}\frac{x_B}{f}\right)}$$

$$= \frac{(Y_A - Y_B)\left(-Z_B\frac{f}{y_A} + Z_B\frac{f}{y_B}\right) - (X_A - X_B)\left(-Z_B\frac{x_A}{y_A} + Z_B\frac{x_B}{y_B}\right)}{(X_A - X_B)\left(-Z_B\frac{f}{y_A} + Z_B\frac{f}{y_B}\right) + (Y_A - Y_B)\left(-Z_B\frac{x_A}{y_A} + Z_B\frac{x_B}{y_B}\right)} \quad \cdots (32)$$

$$\therefore \phi = \mathrm{a}\tan 2\left[\frac{(Y_A - Y_B)(-f)(y_B - y_A) - (X_A - X_B)(-x_A y_B + x_B y_A)}{(X_A - X_B)(-f)(y_B - y_A) + (Y_A - Y_B)(-x_A y_B + x_B y_A)}\right] \quad \cdots (33)$$

It becomes. Next, it is [0075] from a formula (21).
[Equation 16]

$$X_{CA}\begin{bmatrix} 1 \\ x_A/f \end{bmatrix} = \begin{bmatrix} c\phi & s\phi \\ -s\phi & c\phi \end{bmatrix}\left\{\begin{bmatrix} X_A \\ Y_A \end{bmatrix} - \begin{bmatrix} X_G \\ Y_G \end{bmatrix}\right\} \quad \cdots (34)$$

$$\begin{bmatrix} X_G \\ Y_G \end{bmatrix} = \begin{bmatrix} X_A \\ Y_A \end{bmatrix} - X_{CA}\begin{bmatrix} c\phi & -s\phi \\ s\phi & c\phi \end{bmatrix}\begin{bmatrix} 1 \\ x_A/f \end{bmatrix}$$

$$= \begin{bmatrix} X_A \\ Y_A \end{bmatrix} + Z_B\frac{f}{y_A}\begin{bmatrix} c\phi & -s\phi \\ s\phi & c\phi \end{bmatrix}\begin{bmatrix} 1 \\ x_A/f \end{bmatrix}$$

$$= \begin{bmatrix} X_A \\ Y_A \end{bmatrix} + Z_B\frac{f}{y_A}\begin{bmatrix} c\phi - s\phi\cdot\frac{x_A}{f} \\ s\phi + c\phi\cdot\frac{x_A}{f} \end{bmatrix} \quad \cdots (35)$$

The result to say is obtained. Since it asked for a parameter [XG and YG] required for coordinate transformation, and phi and f above, the focus [X, Y] of the arbitration on a line drawing is convertible for the point on a static image [x, y] by using each formula shown below.
[0076]
[Equation 17]

$$\begin{bmatrix} X_V \\ Y_V \\ 0 \end{bmatrix} = \begin{bmatrix} \cos\phi & \sin\phi & 0 \\ -\sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \left\{ \begin{bmatrix} X \\ Y \\ 0 \end{bmatrix} - \begin{bmatrix} X_G \\ Y_G \\ 0 \end{bmatrix} \right\} \quad \cdots (36)$$

$$\begin{bmatrix} X_C \\ Y_C \\ Z_C \end{bmatrix} = \begin{bmatrix} X_V \\ Y_V \\ 0 \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ Z_B \end{bmatrix} \quad \cdots (37)$$

$$\left. \begin{aligned} x &= \frac{Y_C}{X_C} f \\ y &= \frac{Z_C}{X_C} f \end{aligned} \right\} \quad \cdots (38)$$

[0077] Moreover, the point [X1 and Y1] of the both ends of the line on a line drawing, and [X2 and Y2] are changed into the point on a static image [x1 and y1], and [x2 and y2] by the formula (36) - the formula (38). The line drawing corresponding to a static-image top can be piled up by connecting these points [x1 and y1], and [x2 and y2].
[0078] Furthermore, by counting a formula (21) and a formula (27) backward, as shown in a degree type, coordinate transformation of the destination on a static image [x', y'] can be carried out to the point on a line drawing [X', Y'].
[0079]
[Equation 18]

$$\begin{bmatrix} X' \\ Y' \\ 0 \end{bmatrix} = \begin{bmatrix} c\phi & -s\phi & 0 \\ s\phi & c\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \left\{ X'_C \begin{bmatrix} 1 \\ x'/f \\ y'/f \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ Z_B \end{bmatrix} \right\} + \begin{bmatrix} X_G \\ Y_G \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} c\phi & -s\phi & 0 \\ s\phi & c\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \left\{ -Z_B \cdot \frac{f}{y'} \begin{bmatrix} 1 \\ x'/f \\ y'/f \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ Z_B \end{bmatrix} \right\} + \begin{bmatrix} X_G \\ Y_G \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} c\phi & -s\phi & 0 \\ s\phi & c\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -Z_B \cdot \frac{f}{y'} \\ -Z_B \cdot \frac{x'}{y'} \\ 0 \end{bmatrix} + \begin{bmatrix} X_G \\ Y_G \\ 0 \end{bmatrix} \quad \cdots (39)$$

$$\therefore \begin{bmatrix} X' \\ Y' \end{bmatrix} = \begin{bmatrix} c\phi \left(-Z_B \cdot \frac{f}{y}\right) + s\phi \left(Z_B \cdot \frac{x'}{y'}\right) + X_G \\ s\phi \left(-Z_B \cdot \frac{f}{y}\right) + c\phi \left(-Z_B \cdot \frac{x'}{y'}\right) + X_G \end{bmatrix} \quad \cdots (40)$$

[0080] Next, although other operation gestalten of this invention are explained, below, the same sign is given to the part which carries out phase correspondence with drawing 1 , and it explains focusing on difference with the 1st operation gestalt.

(2nd operation gestalt) Drawing 9 is the block diagram showing the configuration of the autonomous remote fusion control system concerning the 2nd operation gestalt of this invention. This drawing shows a control-system system more to a detail.

[0081] There are a mechanical component 100, the migration Planning Department 102, the robot center-of-gravity movement Planning Department 103, the movement control section 104, the servo control section 105, the servo driver 106, sensor I/O 107, the sensor signal transduction section 108, the dead REKONINGU body detection section 109, the performance information processing section 110, the migration information processing section 111, the exception-processing section 112, the servo exception-handling section 114, the kinematic-control exception-handling section 115, the operating state exception-handling section 116, the migration condition exception-handling section 117, and a database 121,124 in a robot side. On the other hand, there are the image display machine 9, a mouse 12, the intellectual remote-control section 130, the display process section 113, the movement actuation information processing section 118, the actuation information processing section 119 of operation, and a database 120 in an operating set side. Here, a robot and operating set side shall perform an exchange of the data through the boundary shown by the dotted line with the communication devices 3a and 3b shown by drawing 1 .

[0082] In this autonomous remote fusion control, Operator MAN performs target assignment on the 2-dimensional map which operated the mouse 12 and was displayed on the image display machine 9. At this time, the 2-dimensional map beforehand recorded on the database 120 is displayed independently.

[0083] The intellectual remote-control section 130 carries out coordinate transformation of the target specified by Operator MAN to the destination on a robot map, and outputs the data A to the migration Planning Department 102. Here, Data A shall show a robot's 1 moving trucking by some destinations a and b and c--.
[0084] The migration Planning Department 102 outputs one at a time to the robot center-of-gravity movement Planning Department 103 as data B with migration of the destination data a, b, and c contained in reception and Data A in the data A in which the moving trucking inputted from the intellectual remote-control section 130 is shown, and the robot 1 which mentions -- later.
[0085] The robot center-of-gravity movement Planning Department 103 plans the optimal center-of-gravity rate based on the data B inputted from the migration Planning Department 102, and outputs to the movement control section 104 as center-of-gravity rate command data C.
[0086] The movement control section 104 is the feedback data NC inputted from the center-of-gravity rate command data C inputted from the robot center-of-gravity movement Planning Department 103, and the kinematic-control exception-handling section 15. It is based, the joint angle (an include angle, angular velocity) of the wheel and steering for realizing suitable center-of-gravity movement and the command angle of a camera mount (pan tilt) are searched for, and those data D are outputted to the servo control section 105. In addition, feedback data NC When those with a body which are mentioned later are shown, it is determined that the command angle of a wheel and a steering joint angle will degenerate a robot's 1 action.
[0087] The servo control section 105 is the feedback data NS inputted from the data D inputted from the movement control section 104, and the servo exception-handling section 114. It is based and the angular-velocity data E of the motor to the wheel and steering, and pan tilt which are made the optimal are outputted to the servo driver 106.
[0088] The servo driver 106 receives the angular-velocity data E of the motor of a wheel and a steering, and a pan tilt inputted from the servo control section 105, and supplies the electrical potential difference or current value for generating the angular velocity which each motor of a mechanical component 100 was ordered. As this result, a robot 1 moves and whenever [angle-of-coverage / of a camera] changes.
[0089] At this time, sensor I/O 107 changes the raw sensor information F (analog data) into reception from a mechanical component 100, changes it into the digital data inside a calculating machine, and outputs it to the sensor signal transduction section 108 as sensor information G.
[0090] The sensor signal transduction section 108 changes the sensor information G (digital data) inputted from sensor I/O 107 into physical quantity, such as a wheel and a steering joint angle, a distance sensor detection value, CCD camera information (still picture), and a pan tilt angle. And data MS in which a wheel, a steering joint angle, and a pan tilt angle are shown It outputs to the servo exception-handling section 114, and the data H in which a wheel and a steering joint angle, a distance sensor detection value, and CCD camera information (still picture) are shown are outputted to the dead REKONINGU object identification section 109 and the movement actuation information processing section 118.
[0091] The servo exception-handling section 114 is the data MS in which the wheel and steering joint angle inputted from the sensor signal transduction section 108, and a pan tilt angle are shown. It is the feedback data NS as it is. It carries out and outputs to the servo control section 105. Moreover, data MS inputted into the database 124 based on the wheel, the abnormality data in a steering joint angle, and the abnormality data in a pan tilt angle which are memorized beforehand When the wheel, steering joint angle, and pan tilt angle which are shown are judged to be abnormalities (for example, movable range over), the abnormality blackboard 125 of an internal memory is made to memorize by making them into abnormality information.
[0092] Based on the data H in which the wheel and steering joint angle inputted from the sensor signal transduction section 108, a distance sensor detection value, and CCD camera information (still picture)

are shown, the dead REKONINGU object identification section 109 asks for a robot's 1 center-of-gravity location from a wheel and a steering joint angle, and judges the existence of the body within fixed distance from a distance sensor detection value. And data MP in which the existence of a center-of-gravity location and a body is shown It outputs to the kinematic-control exception-handling section 115. Moreover, the data I in which a center-of-gravity location, CCD camera information, and distance information are shown are outputted to the performance information processing section 110.
[0093] The kinematic-control exception-handling section 115 is the data MP in which the existence of the center-of-gravity location and body which were inputted from the dead REKONINGU object identification section is shown. It considers as the feedback data NC as it is, and outputs to the movement control section 4. Moreover, data MP Data MP when the center-of-gravity location to depend is judged to be unusual by the database 121 as compared with the center-of-gravity malposition data memorized beforehand When those with a body are shown, it swerves and the abnormality blackboard 123 which is an internal memory is made to memorize by making ** into abnormality information.
[0094] Here, while abnormalities are detected neither in the server exception-handling section 114 nor the kinematic-control exception-handling section 115, the same processing will be repeated according to the moving trucking shown by the destination data a, b, and c stored in the migration Planning Department 102, and autonomous migration will be continued only by the robot 1.
[0095] By the way, in this example, the performance information processing section 110 and the migration information processing section 111 shall have only the function which raises through the data inputted from the lower level to an upper level. Moreover, the operating state exception-handling section 116 and the migration condition exception-handling section 117 are not processing especially in this example. When abnormality decision of operating state and abnormality decision of a migration condition are required for these operating state exception-handling section 116 and the migration condition exception-handling section 117, it is for performing suitable processing in response to the data from the performance information processing section 110 and the migration information processing section 111, and a suitable function is added if needed. For example, the object identification which exists in the distant place of several 10m beyond by preparing a laser range finder as a sensor is made possible. When it seems that a robot 1 is moved at high speed, the laser distance information sent to the performance information processing section 110 from the lower level is given to the operating state exception-handling section 116. Laser distance information is analyzed in the operating state exception-handling section 116, if it is below a threshold, an alarm and laser distance information are given to the robot center-of-gravity movement control section 103 as those with a body, and it is possible to decelerate a center-of-gravity rate command at a predetermined rate by the robot movement control section 103. Moreover, it shall have only the function which raises through the data into which the movement actuation information processing section 118 and the actuation information processing section 119 of operation were also inputted from the lower level here to an upper level.
[0096] Therefore, in this example, the data H outputted from the dead REKONINGU object identification section 119 are inputted into the exception-processing section 112 as data K through the performance information processing section 110 and the migration information processing section 111 as it is.
[0097] The exception-processing section 112 outputs the center-of-gravity location, CCD camera information, and distance information which are shown by the inputted data K to the display-processing section 113 as a robot's 1 abnormality situation data Q, when it is judged as those with a body ahead of a robot 1 in the kinematic-control exception-handling section 115 when a robot 1 cannot continue autonomous working for example.
[0098] If the abnormality situation data Q are inputted from the exception-processing section 112, the display process section 113 will display the center-of-gravity location, CCD camera information, and distance information which are shown by the abnormality situation data Q on the image display machine

9, and will demand a robot's 1 remote operation from an operator. At this time, the display process section 113 piles up and displays the still picture shown using the CCD camera information in the abnormality situation data Q, and the 2-dimensional map which is inputted from the intellectual remote-control section 130 and by which coordinate transformation (enlarging or contracting, advancing side by side, rotation, etc.) was carried out.
[0099] Then, if an amendment orbit is inputted by the operator like the 1st operation gestalt, the autonomous migration by the robot 1 will be resumed like the case where it mentions above based on the amendment orbit.
[0100] (3rd operation gestalt) Drawing 10 is drawing showing the appearance of the autonomous remote fusion control system concerning the 3rd operation gestalt of this invention. This operation gestalt is an example of application to the outdoor monitor robot of various plants, or a works and a warehouse, (a) expresses an outdoor monitor robot and (b) expresses the monitor room.
[0101] As shown in drawing 10 (a), the outdoor monitor robot 200 has a steering driving shaft and a transit driving shaft in each of four wheels 203, and is easily taken as that it can run also by ******** by spot revolution, slanting migration, etc. Moreover, the path of a wheel 203 is enlarged, a suspension is optimized, a curbstone is overcome, and a building etc. can be approached now. Furthermore, the body serves as a waterproofing specification.
[0102] The sensor 201 which has a CCD camera for telling an operator the ultrasonic sensor for obstruction cognition and the situation at that time is formed in the center section of a body. Moreover, the sensor 205 for detecting the abnormal occurrence of perimeters, such as a fire 206, is installed by the hand of the manipulator 204 formed in anterior part. As a sensor 205, an other unit type radiation thermometer, an inflammable gas sensor, etc. are used.
[0103] Moreover, the communication device for communicating with an operating set is formed in the interior of a body, and the antenna 202 is installed in the body right lateral section. On the other hand, as shown in drawing 10 (b), the communication device 208, the loudspeaker 209, and the image display machine 210 are formed in the monitor room side like the 1st operation gestalt, and an operator 207 grasps the outdoor monitor robot's 200 condition with a loudspeaker 209 and the image display vessel 210. In addition, operating sets, such as a mouse, are omitted on the drawing.
[0104] As shown in drawing 11 , this outdoor monitor robot 200 runs autonomously according to the round root 301 in the site set up beforehand. When the outdoor monitor robot 200 has a curbstone at this time, it moves by learning along with that curbstone. Moreover, in the place which does not have a curbstone, dead REKONINGU based on the angle of rotation of a wheel 203 is performed like the 1st operation gestalt, and autonomous migration is carried out, presuming a its present location. In addition, it learns on the basis of the pole 303 formed in the site, and it may move or you may make it presume a your present location using GPS Satellite 302.
[0105] This outdoor monitor robot 200 supervises a perimeter, carrying out autonomous migration of 301 for the round root in a site. Specifically, it is a monitor to the outbreak of gas, a fire, etc., a doubtful person, etc. This is performed using a sensor 201 and a sensor 205. At this time, a sensor 205 can be made to be able to approach an object with a manipulator 204 if needed, and that object can also be supervised more in a detail. In this case, even if an operator 207 operates a manipulator 204 by remote control, when the outdoor monitor robot 200 arrives at the location set up beforehand, you may make it operate a manipulator 204 autonomously.
[0106] By the way, if a front obstruction is recognized during autonomous migration, the outdoor monitor robot 200 will degenerate action like the 1st operation gestalt, for example, will stop a body. Then, the outdoor monitor robot 200 transmits the still picture information incorporated from the CCD camera to the operator 207 of the monitor interior of a room, and makes autonomous migration resume according to the directions of an operator 207 made according to it. By doing in this way, since an operator 207 should just operate it when an obstruction arises ahead of the outdoor monitor robot 200

(i.e., only when it becomes impossible for the outdoor monitor robot 200 to operate autonomously), actuation burden decreases and he can perform the monitor of various plants, or a works and a warehouse easily.

[0107]

[Effect of the Invention] When a robot performs autonomous migration based on the knowledge base set up beforehand fundamentally according to this invention as explained above, and it is judged that the autonomous migration is impossible, Until it is judged in response to the moving target which autonomous migration was degenerated, transmitted the situation data in which a current situation is shown to the operating set, and was taught in the operating set based on the situation data that the autonomous migration based on the knowledge base is possible again Since autonomous migration is performed based on the moving-target data based on an operator's remote operation, a robot can be moved uniting autonomous control and remote control appropriately. Therefore, it can arrive at the destination correctly also by the robot which does not have advanced autonomy, being supported by the operator.

[0108] Moreover, since autonomous migration is degenerated first and it is asking for remote operation by the operating set when autonomous migration of a robot becomes impossible, even when an obstruction is generated, for example ahead of a robot, insurance can fully be secured.

[0109] And since an operating set only teaches the moving target of an action module unit to a robot, there can be few burdens of an operator, and can end and the means of communications to which real time nature, such as PHS, is not necessarily guaranteed can also operate by remote control appropriately further.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] It is the robot control system to which this robot is moved while performing data communication between a robot and an operating set. Said operating set A display means to display the data transmitted by the data set up beforehand and said robot in order to teach said robot, It has an instruction means for teaching the moving-target data of the action module unit which should be transmitted to said robot on the display screen of this display means. Said robot A knowledge base storage means by which the knowledge base for the autonomous migration set up beforehand was memorized, A decision means to judge whether the autonomous migration based on the knowledge base memorized by this knowledge base storage means is possible, When it is judged by this decision means that the autonomous migration based on said knowledge base is possible, autonomous migration is performed based on said knowledge base. When it is judged that the autonomous migration based on the knowledge base is impossible, after degenerating current autonomous migration, The robot control system characterized by having an autonomous migration means to perform autonomous migration based on the moving-target data to which the situation data in which a current situation is shown were taught by said operating set with said instruction means based on delivery and this situation data.
[Claim 2] The robot control system according to claim 1 characterized by displaying the data transmitted by the data beforehand set to said indicating equipment in order to teach said robot, and said robot on two or more coincidence, respectively.

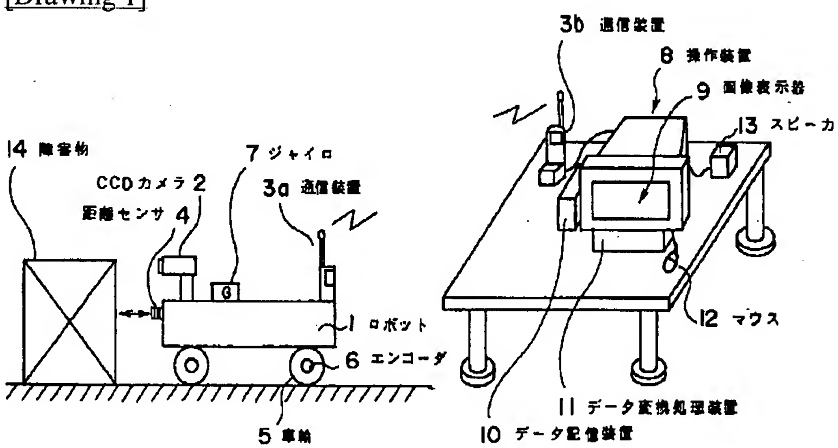
[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

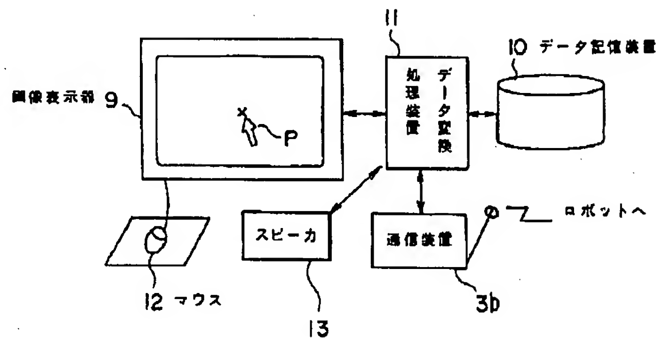
DRAWINGS

[Drawing 1]

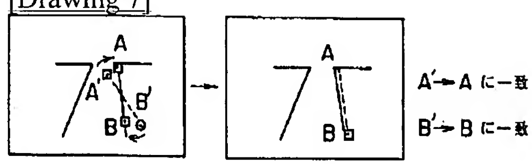


(a) (b)

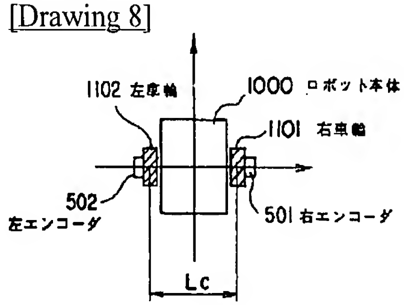
[Drawing 3]



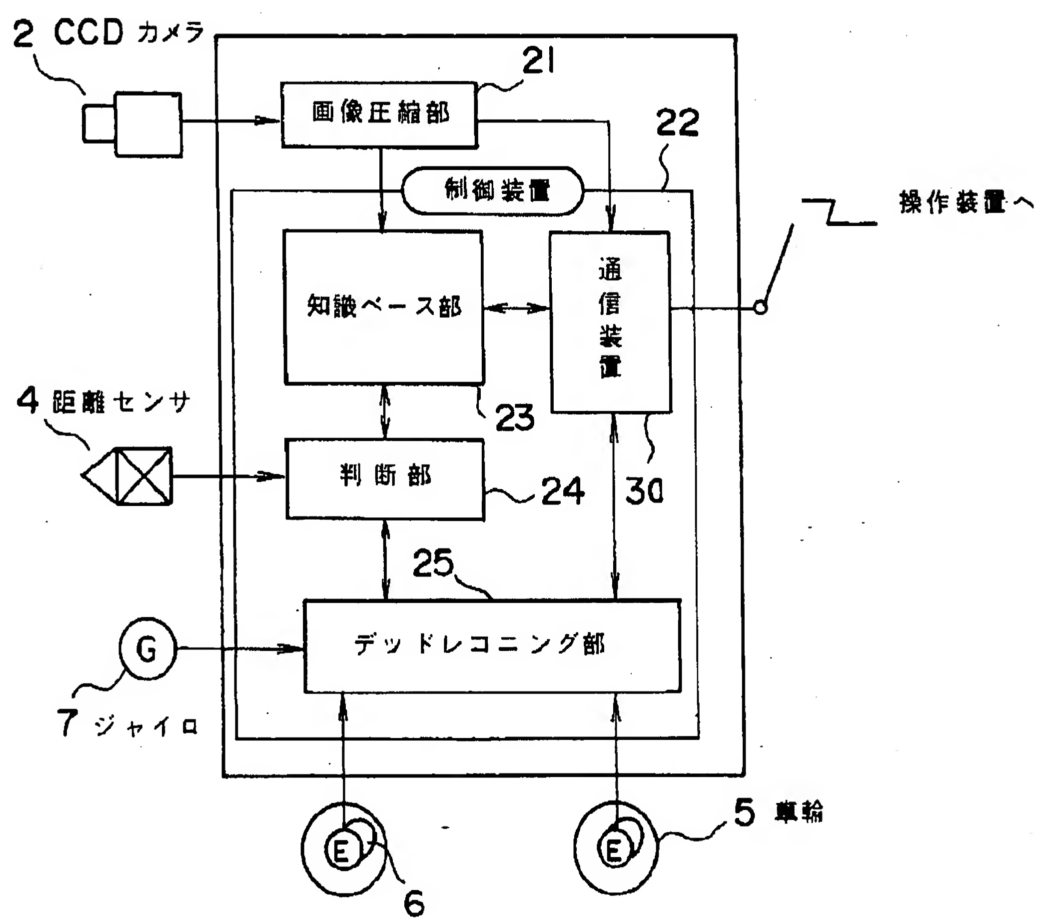
[Drawing 7]



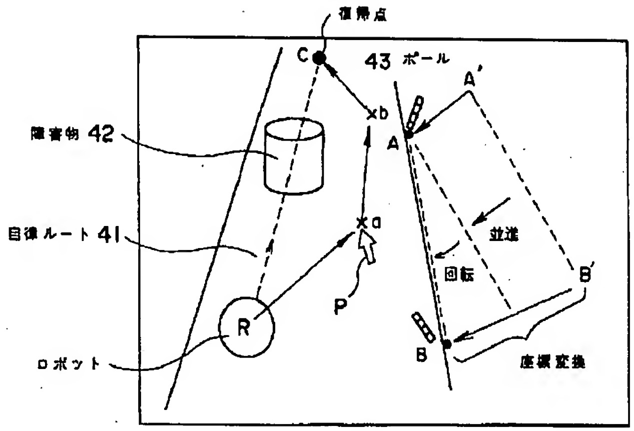
[Drawing 8]



[Drawing 2]


2 CCD カメラ
21
画像圧縮部
22
制御装置
操作装置へ
知識ベース部
通信装置
4 距離センサ
23
判断部
24
30
25
G
デッドレコニング部
7 ジャイロ
E
E
5 車輪
6

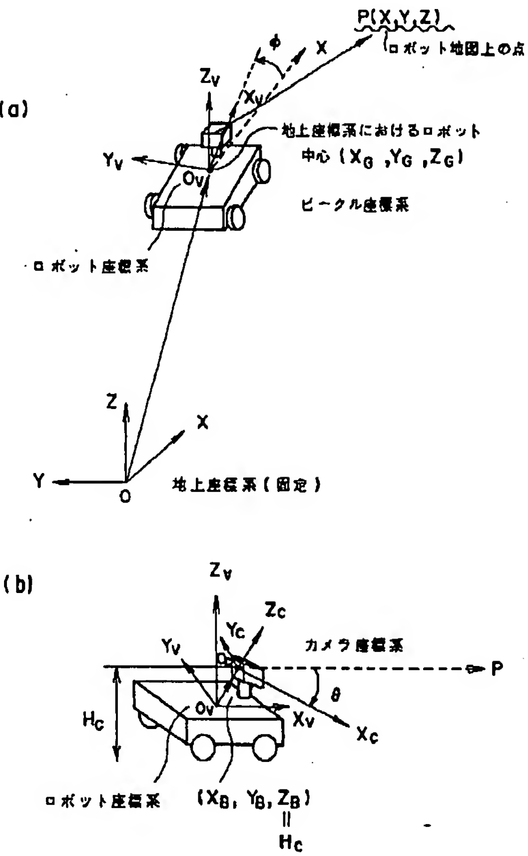
[Drawing 4]



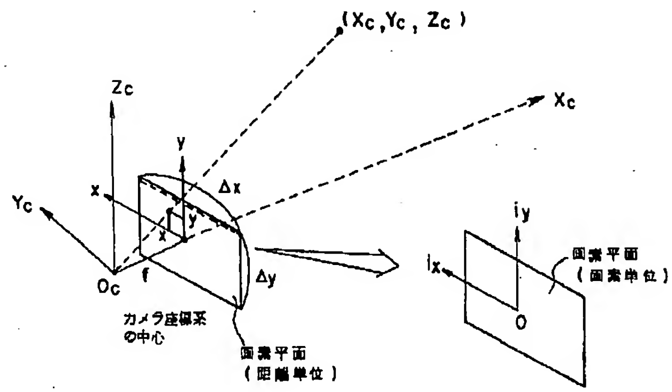
[Drawing 5]

(a)

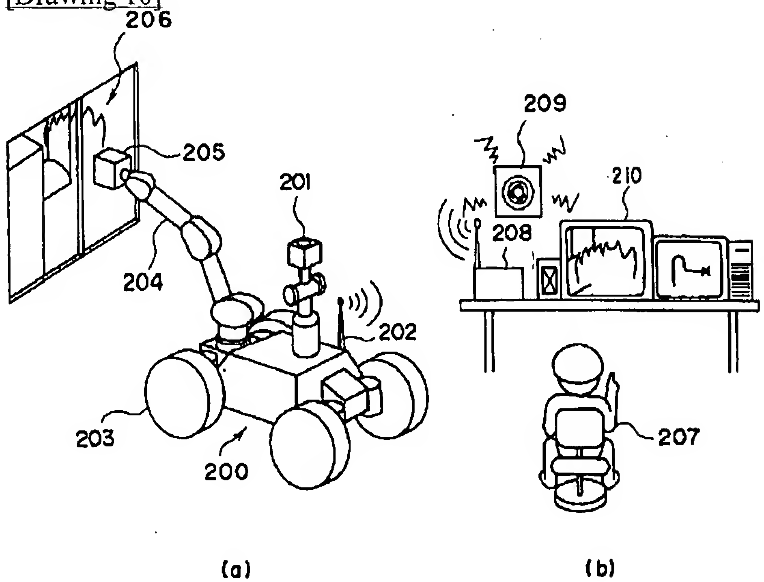
(b)


P(X,Y,Z)
ロボット地図上の点
φ
X
Z_V
X_V
Y_V
O_V
地上座標系におけるロボット
中心 (X_G, Y_G, Z_G)
ビークル座標系
ロボット座標系
Z
X
Y
O
地上座標系（固定）
Z_V
Z_C
Y_C
Y_V
カメラ座標系
P
θ
H_C
O_V
X_V
X_C
ロボット座標系
(X_B, Y_B, Z_B)
‖
H_C

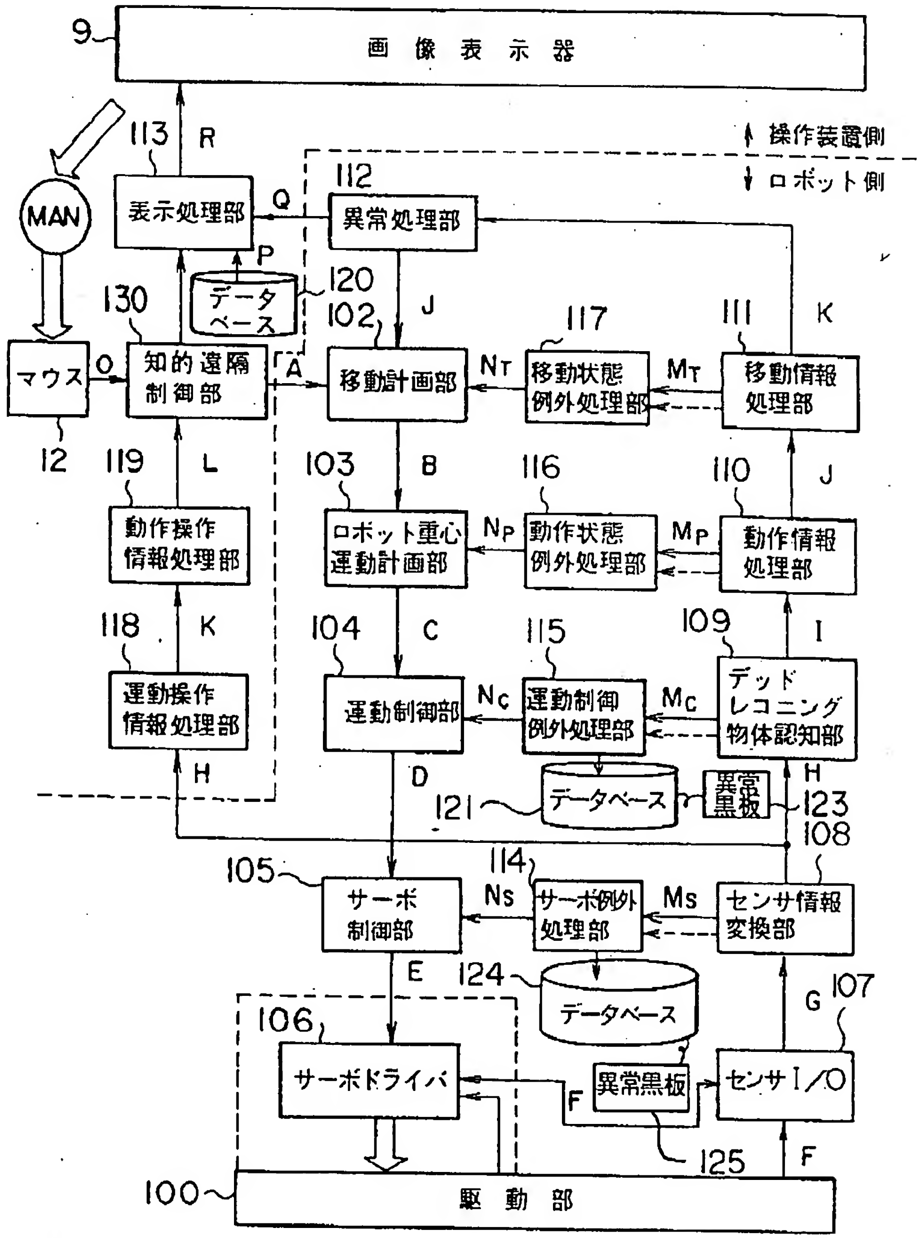
[Drawing 6]



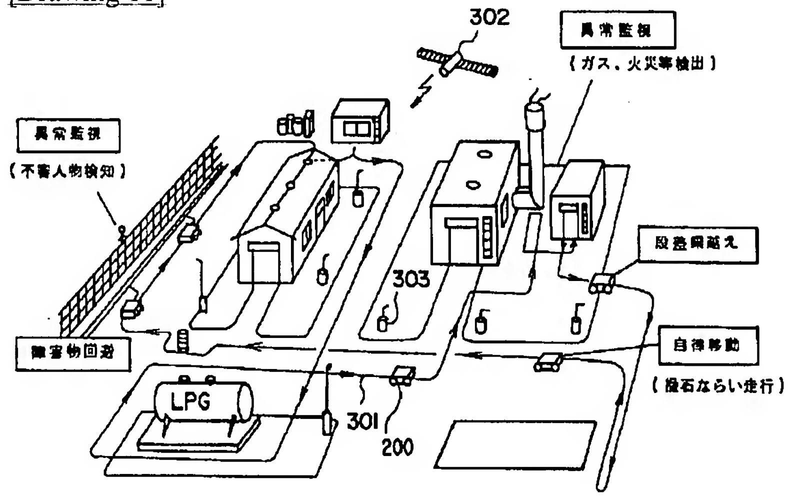
[Drawing 10]



[Drawing 9]


画像表示器
操作装置側
ロボット側
MAN
マウス
表示処理部
異常処理部
データベース
知的遠隔制御部
移動計画部
移動状態例外処理部
移動情報処理部
動作操作情報処理部
ロボット重心運動計画部
動作状態例外処理部
動作情報処理部
運動操作情報処理部
運動制御部
運動制御例外処理部
デッドレコニング物体認知部
データベース
異常黒板
サーボ制御部
サーボ例外処理部
センサ情報変換部
データベース
サーボドライバ
異常黒板
センサI/O
駆動部
9
12
100
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
123
124
125
130
A
B
C
D
E
F
G
H
I
J
K
L
O
P
Q
R
M_T
M_P
M_C
M_S
N_T
N_P
N_C
N_S

[Drawing 11]



[Translation done.]